

Corrosion



CORROSION NOW POSES A DOUBLE THREAT

**Worn out and corroded equipment
may not be replaceable**

Don't take chances on vital equipment. Scarce metals and materials are becoming scarcer. Farsighted business men are rebuilding, repairing and *protecting* to insure continuity of their operations.

Do these two things today:

1. Check up in your plant—manufacturing equipment, piping, valves, tanks, motors, and all similar items.
2. Arrange to protect them with Amercoat—the corrosion-resistant coatings; each designed to meet specialized conditions.

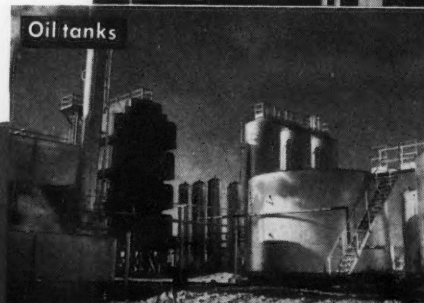
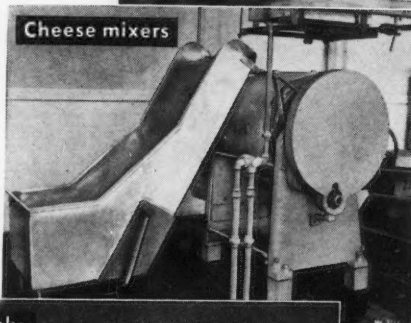
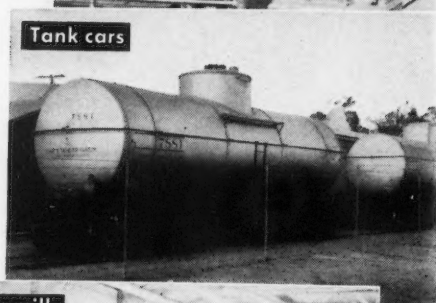
Note: Most conventional coatings fail under severe service conditions. They are neither designed nor suitable for such applications.

AMERCOAT CORPORATION

A Division of American Pipe and Construction Co.
4809 Firestone Blvd., South Gate, California



FOLLOW THE LINE OF
most RESISTANCE



DELAWARE
AQUEDUCT

Everdur

**protects the power
for the world's
biggest drink**

For thirsty New York, the Delaware Aqueduct of the New York City Board of Water Supply performs a service that dares not fail. Hence, Everdur Electrical Conduit is used to protect feed wires for sluice gate motors, pump motors and recording instruments in corrosive locations. Thousands of feet of $\frac{3}{4}$ " and 1" RC and EMT are in service at control stations and inspection elevators along the 117-mile tunnel. Junction boxes in important locations are also made of Everdur®... Anaconda's corrosion-resistant copper-silicon alloys.

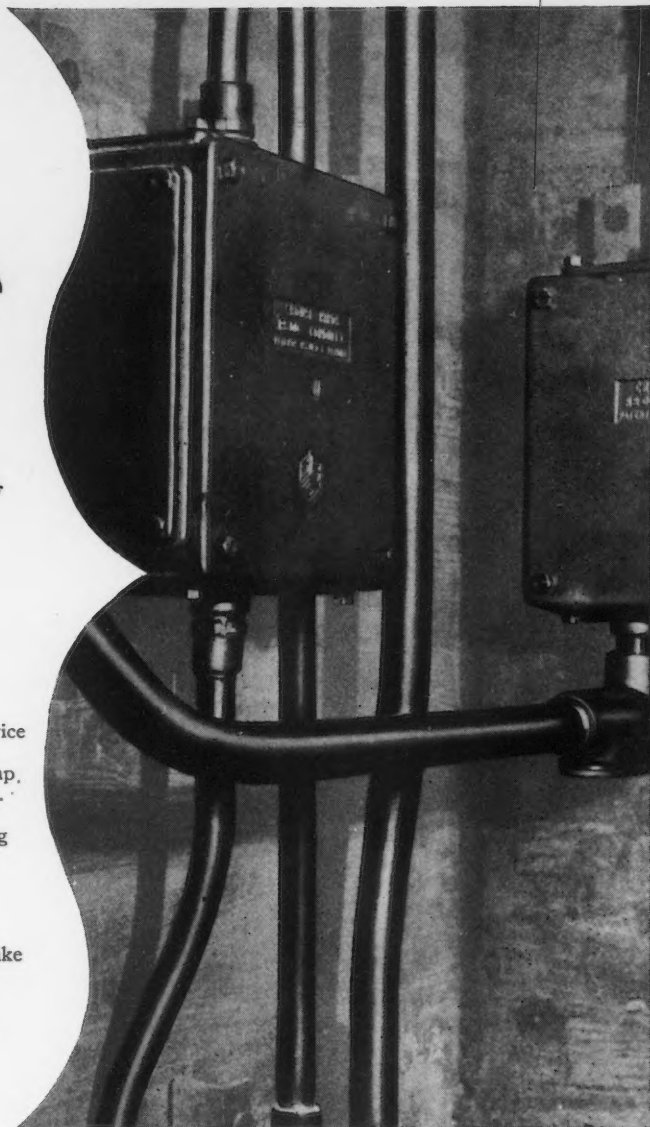
Everdur Conduit has performed impressively on the Delaware River Bridge and in the Pennsylvania Turnpike tunnels where, for many years, it has been exposed to highly corrosive conditions. Installations made since 1933 have shown that where ordinary conduit fails in months, Everdur Conduit lasts for years. It is available in two wall thicknesses: rigid conduit (RC) in nominal sizes from $\frac{1}{4}$ " to 4" inclusive; and the thinner-walled electrical metallic tubing (EMT) in nominal sizes $\frac{3}{8}$ " to 2" inclusive.

Write today for your copy of Anaconda Publication E-12 containing detailed information on Everdur Conduit. Address: The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

51135

Installing Everdur Electrical Conduit on one of the many sluice gate hoists which control the flow of water from the tunnel to the reservoir.

*Reg. U. S. Pat. Off.



Everdur Conduit, 1" RC and $\frac{3}{4}$ " EMT in deep service shaft, Kensico Reservoir control station. Junction boxes are cast Everdur manufactured by Crouse-Hinds.

wherever corrosion resistance counts

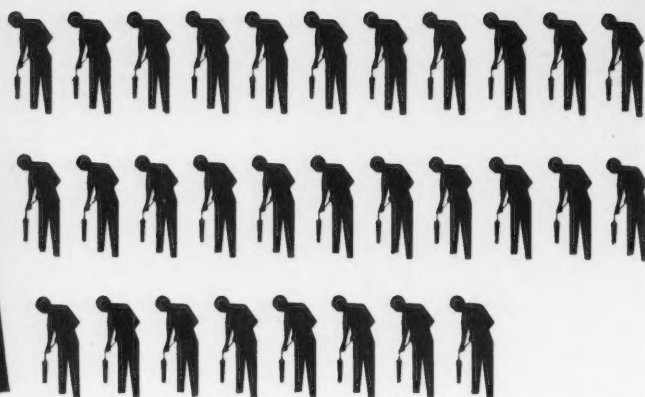
consider

**EVERDUR
ELECTRICAL
CONDUIT**

ANACONDA®

30
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MAGNESIUM
ANODES

prevented



... a 70% reduction in anticipated leak rate

A pipeline company prevented 43 corrosion leaks by installing 30 Dowell magnesium anodes! That's the estimated number of anticipated new leaks avoided in a 2½ year period on a bare, 16-inch underground line with nine corrosive areas totaling 9,000 feet.

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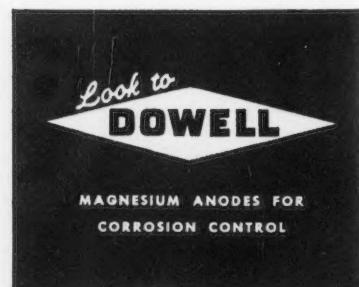
Dowell magnesium anodes offer you maintenance-free, efficient protection against corrosion. They are easily and economically installed, require no external power. The degree of cost-saving protection obtained varies with the particular soil and the number of anodes used for the installation.

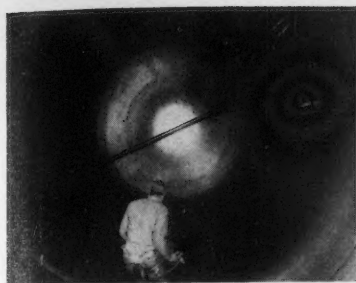
In addition to use on oil and gas pipelines, Dowell anodes have proved valuable in controlling corrosion on municipal gas and water lines, storage tank bottoms, and many other underground and underwater metal structures. Write to Tulsa, Dept. 300 for free booklet and more information.

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MAGNESIUM ANODES
GALVO-PAK® • GALVO-LINE

SUBSIDIARY OF THE DOW CHEMICAL COMPANY





THIS MONTH'S COVER—This formic acid storage tank is being given a phenolic coating. The sandblasted metal received eight coats with a partial curing cycle after the second, fourth and sixth coats by gradually bringing the temperature up to 250 degrees F over two hours and holding at 250 degrees for half hour. Final polymerization cycle involved bringing temperature up to 200 degrees in one hour, raising to 250 degrees in two hours with final cure at 350 degrees for two hours followed by gradual cooling. This was done by the Metallizing Division of Nooter Corp., St. Louis, Mo.



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Corrosion

devoted entirely to
CORROSION
research and control

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MAY, 1951

No. 5



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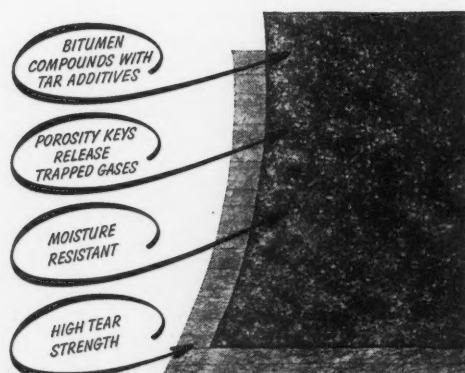
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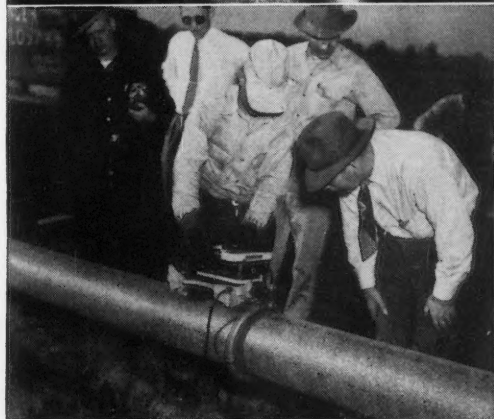
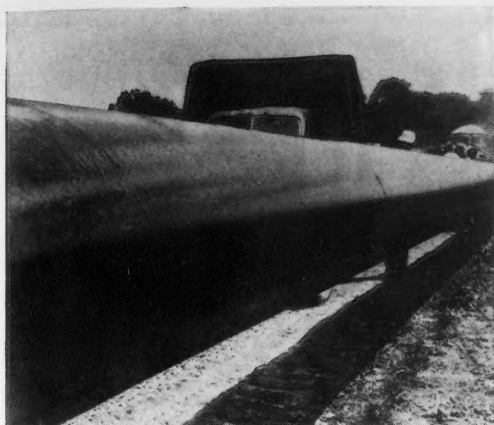
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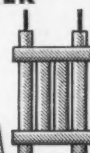
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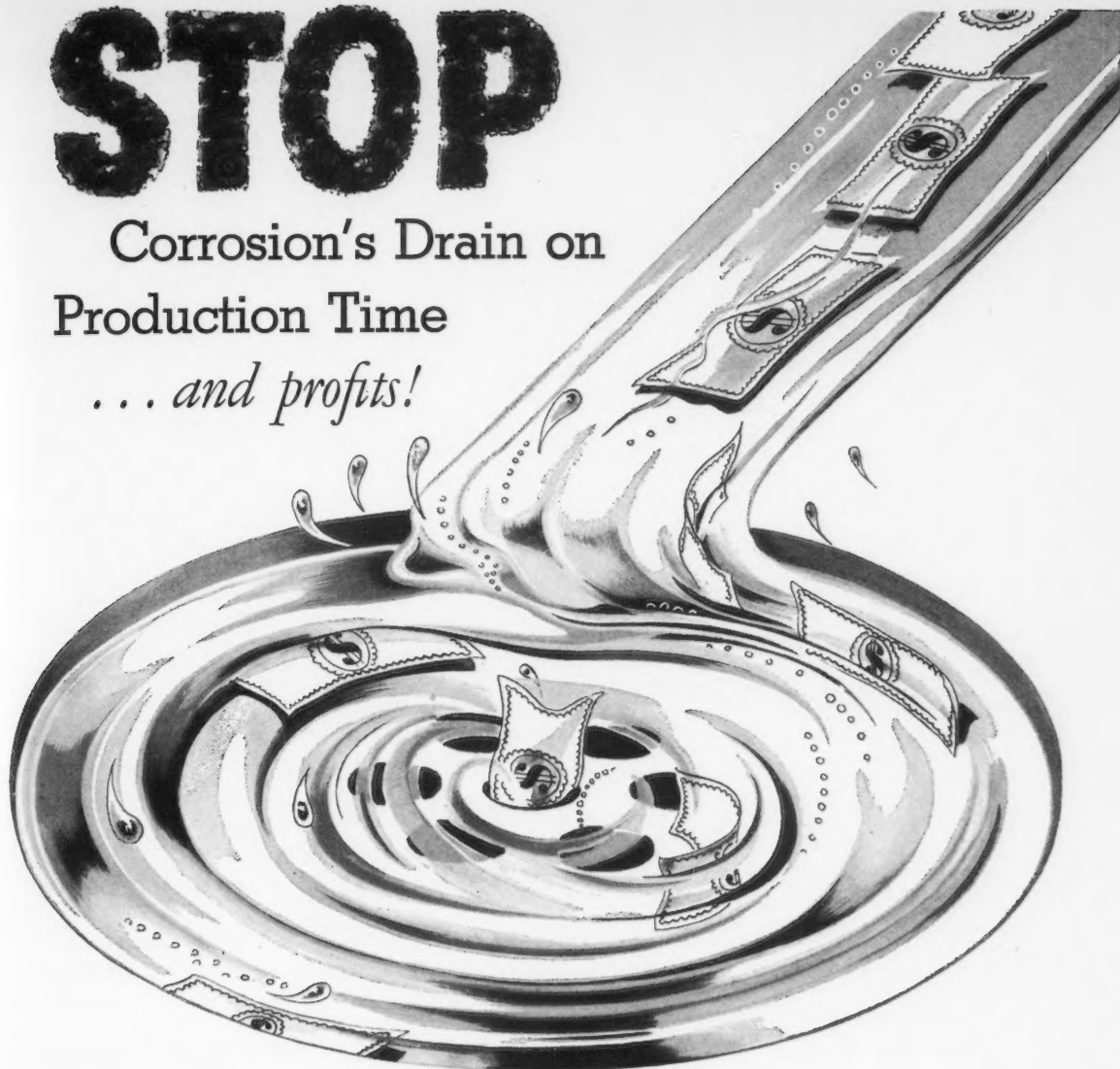
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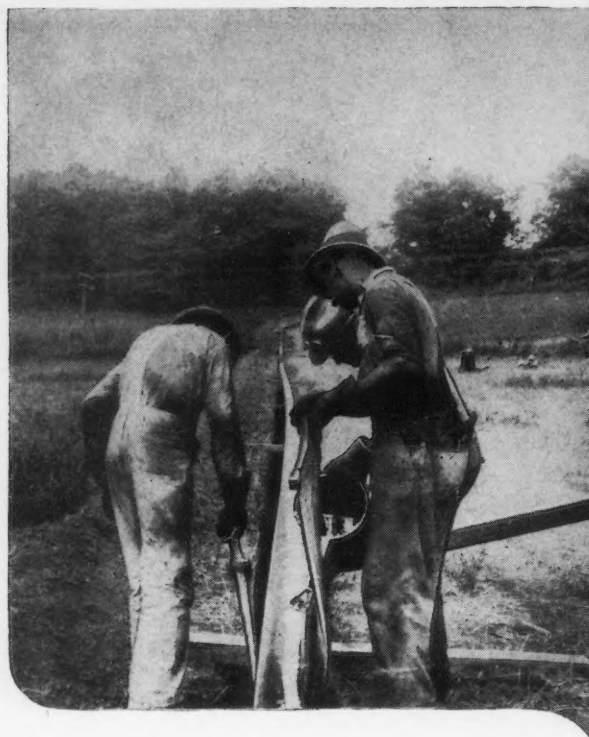
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New Boiler Code Rulings permit Higher Temperatures with INCO Nickel Alloys

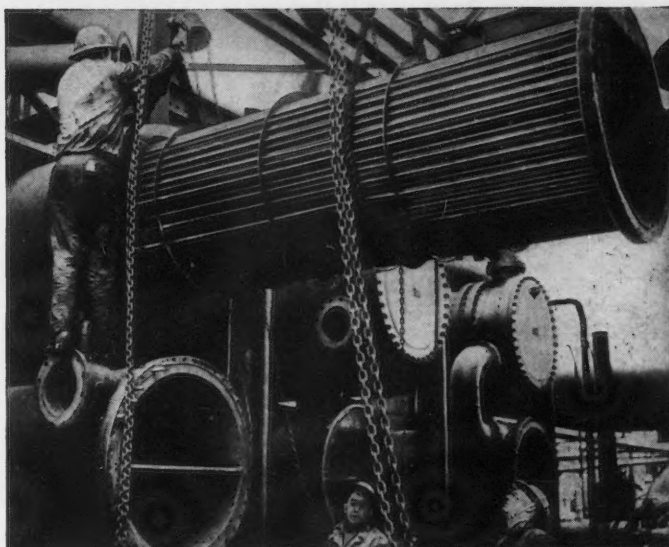
New interpretations of the A.S.M.E. Boiler Code have raised temperature limits on INCO Nickel Alloys used in the construction of unfired pressure vessels.

Also, in addition to annealed Monel, it is now permissible to use stress-relieved Monel, which has substantially higher mechanical properties.

These two modifications of the code mean that it is now possible to build stronger and lighter heat exchangers for higher temperature service, *that are insurable because they are built to code requirements.*

But this modified code applies only to physical properties. To overcome corrosion troubles, users must assume the responsibility for choosing the correct materials.

A glance at the table will show how some users have been able to get greatly increased equipment life by the proper choice of heat exchanger metals...



A cleaned exchanger tube bundle being replaced in its shell. "Spring-cleaning" like this prevents failures in service and insures efficient heat exchange. Photo courtesy The M. W. Kellogg Co., New York, N. Y.

To see if INCO's Corrosion Engineering Service can help you, write, outlining your problem.

And at the same time, ask for a free copy of the new "Boiler Code Interpretations Involving Nickel, Monel, Inconel." It lists the new stress and temperature limits for the INCO Nickel Alloys.

OPERATING HISTORIES OF MONEL HEAT EXCHANGER TUBING

Case No.	Products Handled		Highest Temperature	Service Life		
	Inside tubes	Outside tubes		Previous Material	Monel tubes	Condition of Monel at last inspection
1	Steam	Caustic	350	2-8 weeks	17 months	Good—still in service
2	Foul Caustic	Steam	300	5 months	25 months	No evidence of corrosion
3	Heavy recycle	Straight run gasoline distillate	550	6665 hours	38,535 hours	Renewed 24 tubes after 22,000 hours—3 tubes plugged at 38,535 hours. Remainder OK.
4	Caustic soda and sodium chloride	Steam	240	10 months	80 months	Good—15 tubes replaced—weld failures
5	Crude oil	Gasoline vapor	300	6-8 months	48-60 months	No inspection

Service information on heat exchangers closely similar to yours is probably not in this table. However, help is available from INCO's Corrosion Engineering Service. From their thousands of data sheets showing corrosion rates in a wide variety of media, it is likely that an answer to your specific problem can be found.

CORROSION—May, 1951

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THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 919 Milam Building, 803 Texas Avenue, Houston 2, Texas.



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Objectives and Progress of Technical Practices Committee 9 - Corrosion Inhibitors

By A. WACHTER*

THERE IS NO DOUBT that inhibitors constitute one of the most useful and important means for combating corrosion. Although corrosion inhibitors are used with great economic advantage in many industrial fields, much more widespread use of them could be made with increased knowledge regarding materials that may act as inhibitors, and their behavior under different conditions. Technical Practices Committee No. 9 on Corrosion Inhibitors was formed to work toward the accomplishment of improvements in the science and technology of corrosion inhibitors. The primary aims of the committee are to obtain and to make available information on corrosion inhibitors, to promote the proper use of inhibitors, to promulgate best technical practices for evaluation of corrosion inhibitors, and to encourage research on inhibitors.

The main activity of Committee TP-9 during the past year was the sponsorship and organization of a Symposium on Industrial Use of Corrosion Inhibitors which was held at the NACE Conference in New York, March, 1951. There were five papers on the program, each dealing with a different industrial field of application. In addition, two other papers on inhibitors for which there was no room in this program were placed in two other symposia of the conference.

The good response to solicitation of papers makes it appear that considerable new information on inhibitors is available and that it would be a worthwhile activity for TP-9 to collect such material. The contributions would be discussed critically by the committee and then issued in collected form with discussion as a report of the committee.

The committee would welcome receiving any new information on corrosion inhibitors, whether derived from laboratory research or from field experience. The contribution may be only one page in length

and be concerned with some limited observation or may be as extended and complete as a paper for publication. The material may be theoretical, experimental or practical in nature. Such contributions should be addressed to the chairman of the committee.

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* Chairman TP-9, Shell Development Co., Emeryville 8, Cal.

A Polarographic Method For the Continuous Determination of the Consumption of Oxygen in Corrosion Tests*

By PAUL DELAHAY

Introduction

THE IDEA of determining corrosion rates by measuring the consumption of oxygen is one of the most successful in the study of corrosion mechanism. As it is pointed out by Evans,¹ the methods based on this principle often enable one to determine a complete corrosion-time curve by using a single specimen whereas only one point of the curve is generally obtained per specimen with other methods. The main disadvantage of the methods based on oxygen consumption measurements is that the rate of oxygen consumption and the rate of corrosion may not be related by a simple relationship because of the possible evolution of hydrogen and the occurrence of side reactions consuming oxygen.

Thorough investigations of the consumption of oxygen in metallic corrosion have been carried out at the Teddington Laboratory by Bengough and his colleagues.^{2,3,4} The principle of their method is to corrode the specimen in a closed vessel and to keep the pressure of oxygen above the solution at a constant value. The amount of oxygen consumed is measured at regular time intervals. Modifications of this method have been reported by Morris and Bryan,⁵ Evans and Hoar,⁶ and Borgmann and Evans.⁷

Speller and Kendall⁸ have determined corrosion rates by passing the corroding solution over the specimen and by measuring the decrease in the oxygen concentration. Forrest, Roetheli, and Brown⁹ have estimated corrosion rates from the amount of oxygen consumed during a corrosion test in a closed vessel. In these methods the oxygen concentration is determined by the Winkler titration,¹⁰ whereas the amount of oxygen consumed is measured by a manometric method in Bengough's method.

With the advent of the polarograph, which is especially suited to the determination of traces of oxygen and other reducible ions and substances, it was to be expected that the possibilities of this new method in the field of corrosion were going to be investigated. However, it was not until Van Rysselberghe and coworkers^{11,12,13,14} carried out their investigations that the usefulness of the polarograph in corrosion studies was fully demonstrated.*



PAUL DELAHAY is Assistant Professor of Chemistry at Louisiana State University, Baton Rouge. He is in charge of the research and teaching in electro-chemistry and instrumental analysis. He is the author or coauthor of more than thirty papers in the field of electro titrations, polarography, electrochemical thermodynamics and corrosion.

Abstract

The corroding solution flows at a constant rate in a cell containing the specimen. The concentration of oxygen at the outlet of the cell is measured by the polarographic method. Continuous recording of the oxygen concentration is possible. The calculation of the rate of oxygen consumption is presented together with a few examples. Corrosion tests in distilled water are possible as well as tests in mixtures of two dissolved gases. The various factors which may cause the rate of oxygen consumption to differ from the rate of corrosion are discussed. A method for computing the relative amounts of ferrous and ferric derivatives resulting from the corrosion of iron is presented.

The idea of using the polarograph in corrosion was originated by Burns¹⁵ who determined corrosion rates by measuring, at regular time intervals by the polarographic method, the concentration of the cation appearing during a corrosion process. This method is not applicable in the case of the formation of an insoluble derivative in the corrosion process, while Van Rysselberghe's method is more general. The principle of the latter method is as follows. The specimen is placed in a closed vessel containing a solution initially saturated with air. The oxygen concentration is measured at regular intervals by the polarographic method. The duration of a test varies from one metal to another but it does not exceed three to four hours. After this delay the oxygen concentration has generally decreased to a small fraction of its original value. The oxygen concentration-time plot is used to characterize the behavior toward corrosion. The advantages of this method are rapidity and simplicity. The main disadvantage is that the duration of a corrosion test is limited to a few hours. Moreover, oxygen cannot be determined in solutions of low electrical conductivity and corrosion tests in such solutions are not possible. These dis-

* Submitted for publication August 24, 1950.

* In addition to references 11-14 see also several theses dealing with the following topics: corrosion of magnesium and its alloys, corrosion of lead-tin alloys, corrosion of steel, study of the inhibitive action of nitrite and study of the inhibitive action of thiourea. These theses are deposited at the Library of the University of Oregon at Eugene.

advantages are eliminated in the modified method which is described in the present paper.

Description of Apparatus

The corroding solution flows at a constant rate in the cell containing the specimen. The concentration of oxygen at the outlet of the cell is measured and the rate of corrosion is computed from the data thus obtained.

A schematic diagram and a photograph of the apparatus are shown in Figures 1 and 2. The specimen *S* is placed in cell *T*₃ (150 ml) which is kept at constant temperature by means of water jacket *J*₂. The solution is stirred by a magnetic device *m* rotated at a constant speed. This magnetic stirrer should preferably be rotated by a synchronous motor since the rate of corrosion varies with the rate of stirring. A conventional motor can be used provided it is fed by a constant voltage transformer. The magnetic stirrer *m* floats on a mercury pool or rotates on a polystyrene support if mercury interferes with the corrosion test. Cell *T*₃ is fed with the air saturated solution by means of a constant level device (tubes *T*₁ and *T*₂). The solution drips into tube *T*₁ at a rate which is higher than the rate of flow in the corrosion cell. The excess of solution is collected in funnel *F*₁ for further use. A siphon connects Tubes *T*₁ and *T*₂. Cell *T*₂ is kept at constant temperature by means of a water jacket *J*₁. The rate of flow is adjusted by inserting a coil of capillary tubing of suitable length between tubes *T*₂ and *T*₃. The oxygen concentration is measured in cell *P* (10 ml) which is provided with a dropping mercury electrode and a mercury pool used as the anode of the polarographic circuit. The capillary tube *d* and the head of mercury are selected in order to obtain a drop time of about 5 to 6 seconds. In this manner the amount of mercury consumed per day does not exceed 5 to 10 ml. The excess of mercury in cell *P* overflows in tube *T* and funnel *F*₃. The rate of flow of the solution is determined by measuring the volume of solution which has passed in a given length of time. Cells *T*₂, *T*₃, *P* and *T* are connected by capillary tubes.

Polarographic Measurements

Two different cases are encountered according to whether the solution contains an electrolyte at an appreciable concentration (0.05 molar or above) or does not. In the first case, the salt in solution is used as supporting electrolyte and a 0.4 percent solution of methylred in alcohol is added to the solution at the rate of 50 drops (2.5 ml) per 10 liters. In the second case, 0.5 ml of a saturated solution of sodium nitrate containing 1 drop of 0.4 percent solution of methylred is introduced in the polarographic cell *P* before each determination of the oxygen concentration. This operation is carried out by means of a small funnel with a long capillary tip inserted in the stopper of cell *P* (not represented in Figure 1). The funnel is connected to the capillary tip by a stopcock which is only open during the introduction of the sodium nitrate solution.*

* Sodium nitrate is used as a supporting electrolyte because oxygen waves are better defined in nitrate than in other electrolytes (see Reference 11).

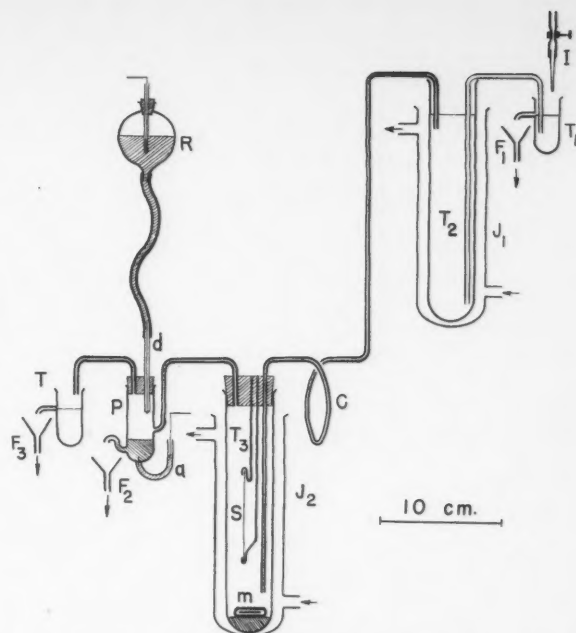


Figure 1—Apparatus for the polarographic determination of the rate of oxygen consumption.

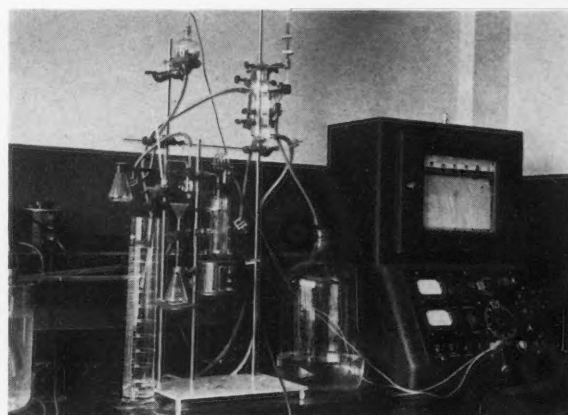


Figure 2—Photograph of the apparatus of Figure 1 with pen-and-ink recording polarograph.

Polarographs of various design can be used. While pen-and-ink recording instruments are the most convenient for the determination of complete waves, manual instruments offer the advantage of enabling one to determine the wave height by measuring the current at two preselected potentials. In this respect the portable electronic instrument for manual determination designed by the author¹⁶ is especially convenient. The automatic recording of the height of the oxygen wave, by measuring the current at a constant potential, is especially useful in the first six or twelve hours of a corrosion test because of the rather rapid variations of the oxygen concentration during this initial period. An automatic recording instrument is under construction in our laboratory at the present. It will be described in a subsequent

paper. For additional information on the polarographic determination of oxygen the reader is referred to Reference 11 and to nomographs on polarography.^{17, 18, 19, 20, 21}

Potential Measurements and External Polarization Circuit

The apparatus described in the present paper is readily adaptable to the measurement of the potential of the corroding specimen as well as to corrosion tests at controlled potential. The potential of the corroding specimen is measured against a reference electrode inserted in the stopper of tube T₃. The specimen is kept at a constant potential by means of an external polarization circuit. The reader is referred to Reference 14 for a complete description of these techniques.

Corrosion in Mixtures of Two Dissolved Gases

A problem frequently encountered in corrosion is the study of the behavior of a metal in a mixture of oxygen and carbon dioxide. Such mixtures are obtained by feeding cell T₃ of Figure 1 with saturated solutions of carbon dioxide. The rate of flow of each solution is adjusted to obtain the desired proportion of dissolved oxygen and carbon dioxide.

Calculation of the Rate of Oxygen Consumption

The rate of oxygen consumption is computed from the obvious relationship:

$$O_2 \text{ consumed} = O_2 \text{ supplied} - O_2 \text{ not consumed}$$

Thus

$$q = (V_o C_o + f t C_o) - (V_o C + f \int C dt) \quad (1)$$

where

- q is the oxygen consumed at time t in mg,
- V_o is the total volume of cell T₃ and P in liters,
- C_o is the concentration of the air saturated solution in mg per liter,
- C is the concentration of oxygen at time t in mg per liter, and
- f is the rate of flow of solution in liters per hour.

Upon differentiation of Formula (1) one obtains the rate of oxygen consumption

$$\frac{dq}{dt} = f(C_o - C) - V_o \frac{dC}{dt} \quad (2)$$

where

$\frac{dq}{dt}$ is expressed in mg per hour, and

$\frac{dC}{dt}$ is expressed in mg per liter per hour

Terms C and $\frac{dC}{dt}$ of Formula (2) are measured on the diagram showing the variations of the oxygen concentration C as a function of t . The value of $\frac{dC}{dt}$ is determined graphically by tracing the tangent to that curve at the point having the coordinates C and t .

The rate $\frac{dq}{dt}$ of Formula (2) corresponds to a concentration of oxygen equal to C . Since concentration

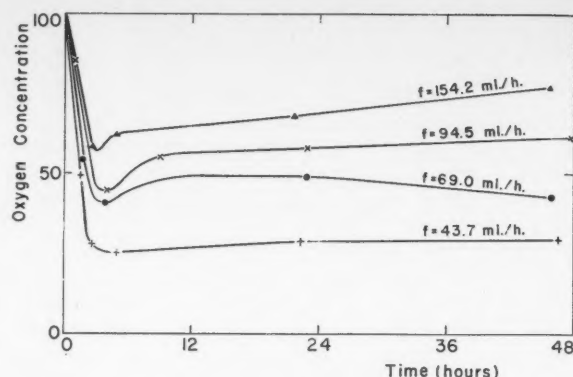


Figure 3—Oxygen concentration as a function of time for various rates of flow of solution. Potassium nitrate 0.05 molar at 33.8°C; iron specimen of 12.0 cm²; initial concentration of oxygen equal to 9.2 mg per liter.

C varies during the experiment it is more convenient to use corrosion rates calculated for an air saturated solution of concentration C_o . One rate is easily converted to the other if one assumes that the rate of corrosion is proportional to the oxygen concentration. This hypothesis, which has been verified experimentally,^{22, 23, 24} is correct provided that the oxygen concentration does not exceed about 6 mg/l (Reference 1, p. 265) and that the carbon dioxide concentration is low.^{24*}

Thus

$$\left(\frac{dq}{dt}\right)_{C_o} = \left(\frac{dq}{dt}\right)_C \times \frac{C_o}{C} \quad (3)$$

or combining formulas (2) and (3)

$$\left(\frac{dq}{dt}\right)_{C_o} = f \frac{(C_o - C) C_o}{C} - V_o \frac{C_o}{C} \frac{dC}{dt} \quad (4)$$

Examples

Corrosion of Iron in 0.05 N Potassium Nitrate

The oxygen concentration is plotted against time in Figure 3 for four rates of flow of the corroding solution. Experiments were carried out at a constant temperature of 33.8°C. The 12 cm² iron specimens were degreased, then cleaned in 6 N hydrochloric acid and finally rinsed with distilled water. All the specimens were cut from the same sheet of metal. The oxygen waves were recorded by means of a Sargent Model XXI polarograph. The average height of the two oxygen waves was used in the calculations. The concentration of the air saturated solution, determined by the Winkler method,¹⁰ was 9.2 mg per liter.

Figure 3 shows that the oxygen concentration, which varies rapidly in the first three hours of the corrosion test, exhibits a minimum and finally reaches a rather steady value after a period extending from eight to twelve hours. The behavior toward corrosion varies from one specimen to another because of

* In the experiments reported in this paper the oxygen concentration was as high as 9.2 mg/l and the proportionality between corrosion rate and oxygen concentration may be considered as a first approximation.

differences in the initial surface conditions of the specimens.

Values of the rate of oxygen consumption calculated by application of formula (4) are plotted in Figure 4. If one takes into consideration the discrepancies resulting from variations in the surface condition from one specimen to another, one observes that the calculated rate of oxygen consumption is independent from the rate of flow of the corroding solution (solid curve) except for the lowest rate ($f=43.7$ ml/h). The rate of oxygen consumption reaches a maximum in the early stages of the test and decreases to a fairly constant value afterwards. The decrease in the rate of oxygen consumption is probably caused by a partial coating of the metal. The appearance of a peak in the diagram of Figure 4 is possibly caused by an initial pitting of the metal or by the dissolution of a protective film.*

The dotted curve of Figure 4 corresponds to the lowest rate of flow, i.e. $f=43.7$ ml/h. Higher values of the corrosion rate are observed. Since this is rather unlikely one concludes that Formula (3) does not apply when the oxygen concentration in the corrosion cell becomes too low. As a provisional rule one may consider that the concentration of oxygen after a period of 12 to 24 hours should not decrease below 40 to 50 percent of the original concentration. To characterize the experimental conditions of a corrosion test we shall define the following coefficient

$$\alpha = \frac{\text{rate of flow in ml/h}}{\text{area of sample in cm}^2}$$

The higher the rate of oxygen consumption, the higher the value of α which should be selected. The minimum value of α which should be adopted is to be determined by an exploratory test of a few hours' duration. Since it is not convenient to adopt a rate of flow exceeding 200 ml/h because of the large volume of solution which would be consumed in a single test, it is preferable to decrease the size of the specimen of a metal exhibiting a high rate of corrosion.

Corrosion of Iron in Distilled Water

The oxygen concentration and the rate of oxygen consumption are plotted against time in Figure 5 for a corrosion test of iron in distilled water. The curve for the rate of oxygen consumption is different from the curve obtained in the case of potassium nitrate. No explanation of this difference will be offered in the present paper since the diagram of Figure 5 is only given as an example. The corrosion of various metals in distilled water is investigated in our laboratory at the present and additional results will be reported in a subsequent paper.

Rate of Oxygen Consumption and Rate of Corrosion

The rate of oxygen consumption determined by the present method, and the rate of corrosion are

* Note that the treatment in 6 N hydrochloric acid should remove any protective film. However, it is possible that a thin film is formed again during the rinsing of the specimen.

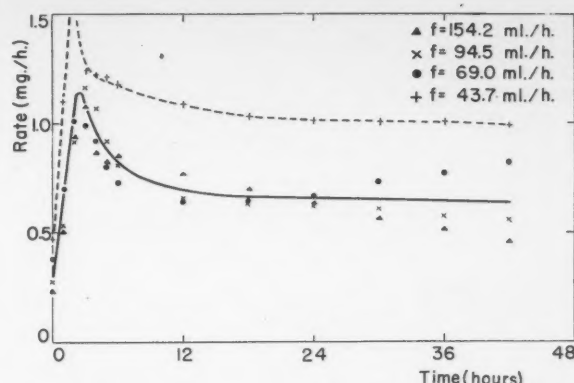


Figure 4—Rate of oxygen consumption as a function of time for various rates of flow of solution. Rates computed from the data of Figure 3 for an area of specimen equal to 12.0 cm², and a concentration of oxygen equal to 9.2 mg per liter.

related by a simple proportionality relationship provided the following conditions are fulfilled:

- 1) The reduction of oxygen should be the only cathodic process occurring in the corrosion process.
- 2) Oxygen should be reduced to water, i.e. there should be no partial reduction of oxygen to hydrogen peroxide.
- 3) The metal undergoing corrosion should be oxidized to a single oxidation state.

Quite frequently one may assume that these conditions are approximately fulfilled. The first condition is approximately fulfilled provided that the solution is neutral and does not contain any cathodic depolarizer besides oxygen. In acid solutions the discharge of hydrogen ion may become the primary cause of corrosion and data on the consumption of oxygen are without significance. In alkaline solutions certain metals such as aluminum and zinc undergo heavy corrosion with evolution of hydrogen and the rate of corrosion is higher than the rate of oxygen consumption. The second condition, i.e. the complete reduction of oxygen to water, is never entirely fulfilled, although in most cases the amount of hydrogen peroxide produced is negligible in comparison with the amount of oxygen consumed. One may thus assume, in calculating corrosion rates, that oxygen is reduced in a process involving four electrons. If this should not be the case, the rate of corrosion still could be computed from the polarographic data. This matter has been discussed elsewhere.¹⁴ The third condition, i.e. the oxidation of the metal to a single oxidation state, is fulfilled for most metals except in the very important case of iron. In this case ferrous and ferric derivations are found in the products of corrosion and the computation of the corrosion rate requires the analysis of the products of corrosion²⁵ or the determination of the relative amounts of ferrous and ferric derivatives according to the following method.

Calculation of the Relative Amounts of Ferrous and Ferric Derivatives in the Corrosion of Iron

The total amount of oxygen consumed during the

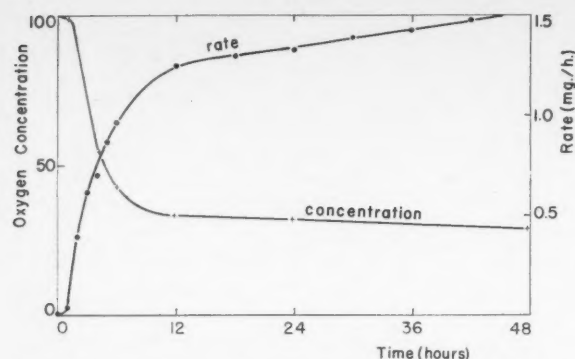


Figure 5—Oxygen concentration and rate of oxygen consumption as a function of time for iron in distilled water at 33.8°C. Area of specimen: 12.0 cm², initial concentration of oxygen equal to 9.2 mg per liter. Rates computed for a concentration of oxygen equal to 9.2 mg per liter.

corrosion test is calculated by application of Formula (1, the value of $\int C \, dt$ being determined by graphic integration. The loss of weight of the specimen is also measured. Taking into account that 32 g of oxygen oxidize 55.85 x 2 g iron to the ferrous state and 55.85 x $\frac{4}{3}$ g to the ferric state one obtains the following equation:

$$\frac{x}{100} \frac{55.8 \times 2 \times q}{32} + \frac{100-x}{100} \frac{55.8 \times 4 \times q}{32 \times 3} = W \quad (5)$$

where

- x is the fraction of the total amount of iron oxidized to the ferrous state in per cent,
- q is the total amount of oxygen consumed in g,
- W is the loss of weight of the specimen in g.

Solving Equation (5) for x one obtains the relative amount of iron oxidized to the +2 state in per cent of the total amount of iron which was oxidized.

Thus

$$x = \frac{W - 2.33 \, q}{0.01165 \, q} \quad (6)$$

It should be pointed out that this method does not give any information on derivatives such as magnetite in which iron has a valence between two and three. Such derivatives are accounted for as ferrous and ferric derivatives.

Conclusion

The present method enables one to determine the rate of oxygen consumption in corrosion tests. The duration of a test is only limited by economical considerations and by the destruction of the specimen. An almost steady rate of corrosion was reached after 24 hours in the experiments reported in this paper and it is quite likely that this would also be the case

in many corrosion tests. The method is especially suited to the study of the variations of the rate of oxygen consumption in the early stages of a corrosion process. The information obtained by this method should prove of special interest in the study of the formation of films and coatings on metallic surfaces as well as in the routine checking of the behavior toward corrosion of many metals. Applications of the present method will be reported in subsequent papers.

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The Chemical Resistance of Phenolic Resins*

By RAYMOND B. SEYMOUR

IN SPITE of their being commercially available for almost half a century and at least an academic knowledge of their chemical resistance having been published, phenolic resins were not used as materials of chemical construction in this country until fairly recently. The delay in such an obvious application may be attributable to American industry's emphasis on novelty in plastics in contrast to the stressing of practicability by the alloy manufacturers. That this approach is not universal is evidenced by the longer industrial use of phenolic resins for chemical resistance and the preference for plastics rather than alloys in foreign chemical industrial construction.

Bakeland patented a coating based on an alkaline-catalyzed alcohol soluble phenolic resin¹ and proposed its use for food container linings over forty years ago.² Several modifications of this general idea were published some twenty years later.^{3,4,5}

Chemical equipment consisting of mixtures of acid-washed asbestos and phenolic resins was manufactured abroad over two decades ago,^{6,7,8} under the trade name Faolite and later in the United States under the name Haveg. Today many chemical firms also purchase proprietary phenolic resin cements and construct their own chemical resistant equipment as needed. Provided sufficient wood or steel reinforcement is supplied, the size of such equipment is almost unlimited but the largest unsupported structure known weighs about two tons.⁹ Adams¹⁰ placed the maximum diameter limit as nine feet and the height as twelve feet for cylindrical tanks and twelve feet square for rectangular equipment although he admits that rectangular units may be joined together to make equipment of almost infinite length.

Corrosive resistant cements based on filled phenol-formaldehyde resins were described by Dietz in 1935¹¹ and later modified by Severs.¹² These products which are now available under the trade names Korez and Asplit are used to the extent of more than five million pounds annually.

Coatings

While filled resins have been proposed for such application,¹³ most phenolic coatings consist simply of an alkaline catalyzed phenol-formaldehyde resin which is applied as an alcohol or ketone solution and cured by the application of heat. It is customary to apply such coatings in multiple layers, to remove the solvent after each coat and cure the entire coating by elevating the temperature to 350° F.^{14,15} While this is the largest use of phenolic resins in the field

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Abstract

Because of their outstanding resistance to solvents, salts and non-oxidizing mineral acids, coatings, chemical equipment and cements derived from phenolic resins are used widely in the chemical, steel, paper, petroleum, food, textile and plating industries. Practical experience and laboratory test data show phenolic resins to be unsuitable for use in presence of nitric acid, chromic acid or strong alkalis but to be resistant to most other common industrial chemicals at temperatures up to 375° F.

A test procedure has been developed in which the weight change of phenol-formaldehyde coupons is determined for various time intervals and specific chemical resistance data are tabulated. Installations are cited in which brick joined with phenolic resin cement have been in continuous hot acid service for over ten years.

of chemical resistance it is being replaced to some extent by thermoplastic coatings based on vinyl chloride copolymers.¹⁶ Phenolic coatings have excellent resistance to solvents, salts and non-oxidizing inorganic acids but are inherently brittle and therefore should not be subjected to heat or mechanical shock. Coatings made from alkylphenols^{17,18} and condensation products of phenol with vegetable oils¹⁹ are more flexible but less resistant to chemical agents than straight phenol-formaldehyde resins.

Chemical Equipment

Pipe and equipment produced by polymerizing an alkaline catalyzed liquid phenol-formaldehyde resin filled with acid-washed asbestos or carbon have been used in this country for over fifteen years and for almost twice as long in Europe. The fact that several major producers of ceramic and alloy equipment have now added filled phenol-formaldehyde resin equipment to their general line is ample evidence of the unsolicited customer acceptance of such material. Considerable information and engineering detail for the manufacture of such equipment has been outlined by Adams.¹⁰

Phenolic resin reinforced with Fiberglas textiles are now being used to protect ceramic equipment and for the production of pipe and chemical appa-

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ratus. While such materials are available commercially, many firms have found it advantageous to tailor-make their own pipe, towers and tank linings using proprietary resinous cements. This general technique has also been used for repairing all types of equipment in the field. In one large chemical plant, a large number of tanks have been constructed by nailing Masonite sheets together and coating the resulting structure with several applications of a carbon-filled phenol-formaldehyde cement.

Cements

At present, there are a large number of distributors of chemical resistant cements based on furfuryl alcohol polymers and phenol-formaldehyde resins but very few firms produce their own liquid resins.²⁰ All information available to date indicates that cements based on furfuryl alcohol are more universally applicable than phenolic cements but the latter are required for specific installations and have a long term performance record that cannot be discredited.

Phenolic resin cements consist of a mixture of an alkaline catalyzed phenol-formaldehyde liquid resin having a solids content of at least 70 percent and a minimum convertible solids content of 90 percent with a corrosion resistant filler. Silica, asbestos, barium sulfate and carbon are the most widely used fillers. Carbon-filled cements have superior working properties and are more resistant to hydrofluoric acid than asbestos or silica-filled products. These cements are prepared by intimately mixing the liquid resin with a properly selected filler containing an appropriate amount of acid catalyst. The working and setting times of the resulting mortar is an inverse function of the temperature. Tests for both of these factors based on techniques that can be duplicated by trained laboratory technicians are being developed.²¹ Attempts to use alkaline or peroxide type catalysts to convert the liquid cements to infusible resins have been unsuccessful. Best results have been obtained using para-toluene sulfonic acid, para-toluene sulfonyl chloride and ethyl hydrogen sulfate.

As evidenced by the data in Table I, commercially available phenolic cements possess working and setting times that make them adaptable for practical masonry construction. For specific applications, these times may be widely varied by changes in catalyst concentration but masons and tile setters, who are accustomed to standard non-plastic products, usually object to such variations.

For practical purposes, the working time of a phenolic cement may be defined as the maximum time in minutes at which the mortar may be buttered on a dry pressed brick surface using a mason's

trowel. This time is influenced by the area and the type of surface as well as the surrounding temperature. For example, the working life of a phenolic resin mortar can be extended by spreading it in a thin layer on a non-conducting surface and further extended by using a conducting surface. The final setting time is considered to be the time in hours in which a phenolic resin cement has attained its maximum resistance to specific chemicals. Prior to this final setting time, there are two significant periods; one in which the cement will support the weight of a brick structure and the other when it cannot be penetrated by a knife blade.

The properties of completely set phenolic cements have been described by Seymour,²² Stepichev²³ and Wirth⁸ and the resistance to specific chemicals and cast asbestos filled phenolic equipment has also been published.^{24, 25, 26, 27} As might be expected, cast phenol-formaldehyde products are more resistant to chemicals than molded or laminated resins.^{28, 29, 30, 31, 32} Delmonte³³ stated that paper-base phenolic laminates lost 20 percent strength after 150 hours in 1 N sulfuric acid, 40 percent after 250 hours in 1 N hydrochloric acid or 100 hours in 6.5 N sodium hydroxide and 60 percent after 8 hours in 15.7 N nitric acid.

Cements may be made by simply mixing paraformaldehyde and filler with liquid cashew nut resins³⁴ and these products are said to be more resistant to alkalis and more soluble in solvents than straight phenolic resins.^{35, 36} Andrianov¹⁷ has outlined the chemical resistance of hexylphenol-formaldehyde resins and van Eijnsberger¹⁹ has discussed the chemical resistance of vegetable oil modified phenolic resins.

In general, phenol-formaldehyde resins are resistant to all non-oxidizing mineral acids such as hydrochloric, phosphoric and dilute sulfuric acid. In spite of slight attack by dilute nitric and chromic acids as well as sodium hypochlorite, the use of phenol-formaldehyde cements in the presence of these materials is usually acceptable at ordinary temperatures. These resins are resistant to salts, weak alkalis, chlorine and most solvents at temperatures up to 370° F but are completely unsatisfactory for use in the presence of sodium or potassium hydroxide in any concentration.

Test Methods

Tests for the chemical resistance of phenolic resins have been published^{27, 38} but none is considered adequate. Several test methods for the determination of chemical resistance of phenolic resin cements are being studied by The American Society for Testing Materials Committee C-3.³⁹ These methods include change in weight of small cylinders, small cubes²⁴ and finely divided specimens as well as the change in resistance of adhesive bonds. The most satisfactory results to date have been obtained by mixing liquid phenolic resins with fillers containing setting agents in accordance with manufacturer's directions, casting test wafers measuring 1-inch x 7/8-inch x 1/8-inch and curing at 90° F for 24 hours followed by three days at 140° F and testing as follows:

Three wafers are weighed on a Gramatic balance to the fourth decimal place in grams and placed in a

TABLE I
Working and Setting Times
For a Commercial Carbon-Filled Phenolic Cement

Temperature (°F.)	Working Time (Min.)	Setting Time (Hrs.)
60.....	180	72
70.....	60	24
80.....	30	15
90.....	15	8

jar with the appropriate solution at room temperature. The same test is repeated at 150° and 194° F. One sample is removed from each test at the end of ten, twenty and thirty days. Likewise, three wafers are placed in distilled water at these three temperatures if the corrosive under test is an aqueous solution. Upon removal from the test solution, each sample is extracted by de-ionized water at a temperature of 175-195° F for eight hours while being supported in a stainless steel wire mesh basket, dried for sixteen hours at 212° F, cooled and re-weighed on a Gramatic balance.

For tests in aqueous solutions, any additional change in weight over that noted in the distilled water expressed as percent change is plotted against time. A zero slope is generally obtained when the product is resistant and relative resistance is determined on the basis of the rate of change with time.

The washing procedure is omitted for water immiscible organic reagents and these values are determined directly after the excess solvent is blotted off the sample with a cloth dampened in the solvent involved. Particular attention is paid to the change in slope between the first two readings in the event that there is a preliminary loss or gain in weight which is not reflected by continuous immersion.

Considerable information is also obtained by noting etching, loss in strength, embrittlement, shrinkage, curling, etc. It is advantageous to expose the maximum amount of surface of the sample and to extend the tests over as long a period as practical. The samples are prepared in sheet form and cut using a template and thus very little actual working time is consumed in this test which supplies considerable data. It is of interest to note that twelve weighings required for each standard test can be accomplished in less than five minutes with the use of a Gramatic balance.

As is evident by the data in Table II, temperature has no deleterious effect on the resistance of either silica or carbon-filled phenolic cement to 25 percent sulfuric acid, 50 percent sulfuric acid, saturated aqueous sodium chloride, mineral or vegetable oil. Both types are resistant to concentrated sulfuric acid and 10 percent nitric acid at room temperature but are attacked by higher temperatures. Both are fairly resistant to 5 percent sodium hypochlorite at room

temperature but are slightly etched. There is little change in weight in alkalis but physical properties of the surface are adversely affected at a pH above 8.5.

The effect of time on the resistance of phenolic cements at 70, 150 and 194° F is shown in Tables III, IV and V. As previously stated, phenol-formaldehyde cements are completely resistant to mineral and vegetable oils, non-oxidizing acids and salts even at elevated temperatures. Sodium carbonate and oxidizing acids have little effect on phenolic cements at room temperature. Carbon-filled phenolic resin cements are more resistant than those filled with silica to sodium carbonate or oxidizing acids.

Because of the lack of resistance of phenolic cements to alkalis, it is of interest to note that carbon-filled polyfurfuryl alcohol cements are completely unaffected by alkali even at elevated temperatures. Data on the resistance of furfuryl alcohol cements to 20 percent sodium hydroxide are given in Table VI.

TABLE III
Effect of Time on Change in Weight of Phenolic Cements at Room Temperature

REAGENTS	SILICA-FILLED (Days)			CARBON-FILLED (Days)		
	10	20	30	10	20	30
25% Sulfuric Acid.....	-0.4	0.2	0	-0.2	0.4	-0.6
50% Sulfuric Acid.....	0.3	-0.1	-0.4	-0.6	-0.6	-1.6
96% Sulfuric Acid.....	0.1	0.3	-0.2	-1.5	-2.6	-2.3
Saturated Aqueous Sodium Chloride.....	0.4	0.1	1.2	0.8	0.4	-1.7
Mineral Oil.....	2.2	0	0	0.9	3.5	3.9
Vegetable Oil.....	0	0	0	2.9	5.1	5.5
10% Sodium Carbonate.....	-0.1	1.1	0.5	-0.2	0.5	-0.8
5% Sodium Hypochlorite.....	-8.1	-3.1†	-10.9†	-1.9	-1.6†	-1.6†
10% Chromic Acid.....	-1.1	-1.7*	-2.4*	-1.5†	-2.6†	-3.6†
10% Nitric Acid.....	2.1	2.0*	2.0*	-0.8	-0.2	-0.3

* Physical properties adversely affected.

† Slightly etched.

TABLE IV
Effect of Time on Percent Change in Weight of Phenolic Cements at 150° F.

REAGENTS	SILICA-FILLED (Days)			CARBON-FILLED (Days)		
	10	20	30	10	20	30
25% Sulfuric Acid.....	0.2	0.5	-0.1	-0.6	-0.5	-0.6
50% Sulfuric Acid.....	-1.1	-0.2	0.8	-1.5	-2.9	-3.0
Saturated Aqueous Sodium Chloride.....	0.7	-0.4	0.1	0.6	-1.1	1.0
Mineral Oil.....	-7.2	0	0	-3.4	-5.4	-6.2
Vegetable Oil.....	0	0	0	-2.6	-4.6	-5.1
10% Sodium Carbonate.....	0.9*	0.1*	0.9*	-0.1	-1.6	0.8
10% Chromic Acid.....	-3.1	-5.2*	-5.0*	-9.1	-12.1†	-9.0†
10% Nitric Acid.....	.....	.....	.....	-1.9*	-5.3*	-24.0*

* Physical properties adversely affected.

† Slightly etched.

TABLE V
Effect of Time on Percent Change in Weight of Phenolic Cements at 194° F.

REAGENTS	SILICA-FILLED (Days)			CARBON-FILLED (Days)		
	10	20	30	10	20	30
25% Sulfuric Acid.....	1.2	-0.2	0	-3.7	-0.4	-2.4
50% Sulfuric Acid.....	0.7	0.2	0.9	-3.5	0.1	-3.0
Saturated Aqueous Sodium Chloride.....	-0.2	0.3	0	-0.5	-0.8	-2.9
Mineral Oil.....	0	0	0	4.0	18.6	7.1
Vegetable Oil.....	0	0	0	3.3	0	7.5
10% Sodium Carbonate.....	-0.3*	-2.5*	-2.2*	-2.3	-0.8	-2.4
10% Chromic Acid.....	-3.3*	-5.0*	-4.7*	-10.3†	-4.4†	-34.9*
10% Sulfuric Acid.....	.....	.....	.....	.....	.....	.....

* Physical properties adversely affected.

† Slightly etched.

TABLE II
Percent Change in Weight of Phenolic Cements in Various Solutions at Different Temperatures (10 Days' Exposure)

REAGENTS	SILICA-FILLED (°F)			CARBON-FILLED (°F)		
	70	150	194	70	150	194
25% Sulfuric Acid.....	-0.4	0.2	1.2	-0.2	-0.6	-3.4
50% Sulfuric Acid.....	0.3	-1.1	0.7	-0.6	-1.5	-3.5
96% Sulfuric Acid.....	0.1	.....	.....	-1.5	.....	.....
Saturated Aqueous Sodium Chloride.....	0.4	0.5	-0.2	0.8	0.6	-0.5
Mineral Oil.....	-2.2	-7.2	0	-0.9	-3.4	-4.0
Vegetable Oil.....	0	0	0	-2.9	-2.6	-8.3
10% Sodium Carbonate.....	-0.1	0.9*	-0.3*	-0.2	-0.1	-2.3
20% Sodium Hydroxide.....	0*	0.1*	-1.5*	-21.2*	-100*	-100*
10% Sodium Hypochlorite.....	-8.1†	.....	.....	-1.9†	.....	.....
10% Chromic Acid.....	-1.1	-3.1	-3.3	-1.5	-9.1	-10.3
10% Nitric Acid.....	2.1	-100	-100	-0.8	-1.9	-100

* Samples lost most of original strength.

† Samples slightly etched.

As previously discussed and as shown by the data in Table VII, phenolic resin cements are not resistant to sodium hydroxide but they are more resistant to concentrated than to dilute caustic. This phenomena explains why phenolic resins have been used successfully as jointing materials for floors in the presence of highly concentrated alkali at ordinary temperatures.

Results obtained by this method are quite reproducible even though attack may be severe as in the case of oxidizing inorganic acids. For example, tests on a carbon-filled phenolic cement in the presence of 10 percent nitric acid showed a maximum deviation from the mean value of 10 percent. When good chemical resistance was obtained, such as in the case of 25 percent sulfuric acid, the deviations were much smaller as shown in Table VIII.

Factors Effecting Resistance of Phenolic Resins

The chemical resistance of phenolic resins is a function of the ratio of formaldehyde to phenol used in the preparation of the liquid resin, pH of the initial and final condensation, temperature of resin formation, chain length of the molecule and chemical

TABLE VI

Effect of Temperature on Percent Change in Weight of Polyfurfuryl Cement in 20% Sodium Hydroxide

TIME (Days)	TEMPERATURE (°F.)		
	70	150	194
10.....	0	-1.4	-3.9
20.....	-0.1	-2.7	-1.5
30.....	-0.8	-3.0	-1.0

TABLE VII

Percent Loss in Weight of Silica-Filled Phenolic Resins in the Presence of Aqueous Sodium Hydroxide

TEMPERATURE (°F.)	Time (Days)	CONCENTRATION OF SODIUM HYDROXIDE (%)		
		10	25	40
70.....	10	5.5	0.1	1.9
	20	12.2	3.3	2.0
	30	17.4	0.6	1.2
150.....	3	2.5	2.3	1.1
	7	5.9	5.4	4.4
	14	27.4	11.4	8.4
190.....	(Hrs.)			
	6	2.2	6.4	8.4
	13	5.1	31.4	17.4
	19	19.6	38.4	21.4
	25	61.6	.....	25.4

TABLE VIII

Reproducibility of Corrosion-Resistant Data in 25% Sulfuric Acid

TIME	Percent Change in Weight in Silica-Filled			Percent Change in Weight in Carbon-Filled		
	Minimum	Average	Maximum	Minimum	Average	Maximum
70 °F.:						
10 days.....	0.8	1.0	1.2	-0.1	-1.1	-2.5
20 days.....	0.5	0.5	0.6	0.2	-0.1	-0.3
30 days.....	0.1	0.8	1.5	0.2	0	-0.4
150 °F.:						
10 days.....	0.6	0.7	1.0	-0.5	-1.4	-2.8
20 days.....	0.5	0.6	0.7	-0.3	-0.6	-1.3
30 days.....	-0.8	-0.4	0	1.0	0.3	-0.1
194 °F.:						
10 days.....	0.6	-0.1	-0.8	-2.7	-2.8	-3.3
20 days.....	0	-0.6	-0.7	0.3	-0.5	-0.9
30 days.....	0	-0.2	-0.3	-2.3	-2.6	-2.9

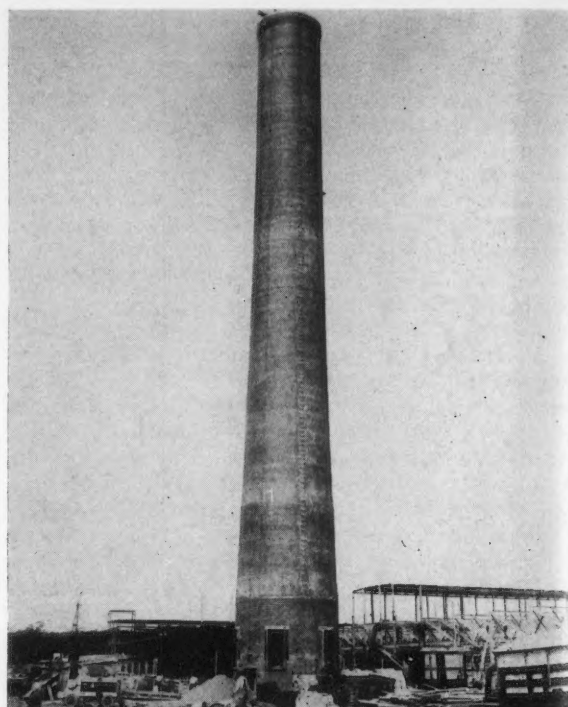


Figure 1—Two hundred foot fume stack constructed of brick and phenol-formaldehyde resin cement.

constitution of fillers or diluents. Cellulose-filled resins are not resistant to acids and asbestos or silica-filled resins are not resistant to hydrofluoric acid but carbon or graphite-filled resins are usually resistant to all non-oxidizing inorganic acids. Carbon-filled phenolic resins are generally more resistant to oxidizing agents than silica-filled products possibly due to an absorption of the resin by the carbon filler.

The adsorption of acids and alkalis by phenolic resins^{40,41} is associated with the molecular weight of the resin but is not a major factor in the mechanics of resistance to chemicals. In practical use, phenolic resins are often sufficiently resistant to oxidizing agents at low temperatures, providing the surface remains undisturbed. Abrasive conditions will remove the oxidized surface and permit further attack. Likewise, some solvents and even weak alkalis will sometimes remove the oxidized surface and permit additional attack by oxidizing agents.

The major uses for phenolic coatings have been in the food industry but phenol resin cements have been widely used for joining brick and tile in floors and walls in the food, chemical, electroplating, paper,⁴² textile,⁴³ leather, steel and petroleum industries. While phenolic cements have not proved satisfactory for floors cleaned with highly alkaline cleaners, they have given excellent service where acids only have been present.

Industrial Uses

Figure 1 shows a stack with a diameter of 15 ft. 6 in. and 200 feet high in which the bricks are joined

with a silica-filled phenolic cement. A recent examination of a similar stack in a rayon plant in which alunite and phenolic cements were used in different sections showed that the former was completely disintegrated after three years of service while the latter was unaffected.

Figure 2 shows a floor in an ice cream plant joined with silica-filled phenolic cement after twelve years of continuous service. Some floors in similar service have been attacked somewhat as a result of the use of highly alkaline detergents but they are completely unaffected by food acids or ordinary cleaning agents.

Figure 3 shows a rubber-lined steel tank protected with brick joined with silica-filled phenolic cement. This is one of five tanks measuring 60 ft. by 7 ft. by 4 ft. operating continuously at 230° F using 25 percent sulfuric acid for pickling of cold stripped steel. Such tanks have been in service for over ten years without visible signs of disintegration.

As previously discussed, phenolic resins, like alloys, often prove to be serviceable in the presence of slow attack by chemicals. However, unlike alloys, no method is available for the estimation of useful life. Phenolic resin structures have been used in the presence of sulfuric acid in Germany for over twenty years and in this country for over ten years. In an industry in which undue stress on novelty has inspired occasional ridicule, it is encouraging to note that in the presence of a wide variety of corrosives, phenolic resins are serving satisfactorily as materials of construction.

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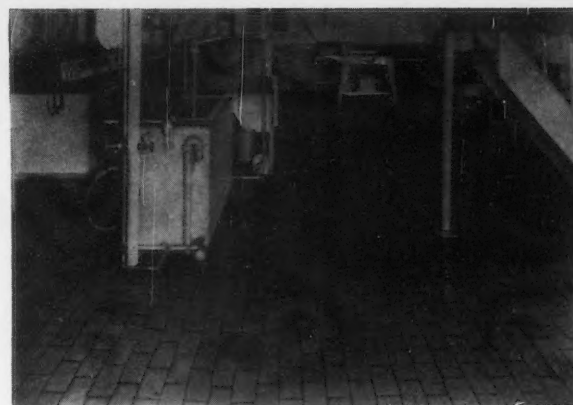


Figure 2—Brick floor joined with silica-filled phenolic cement after twelve years' service.

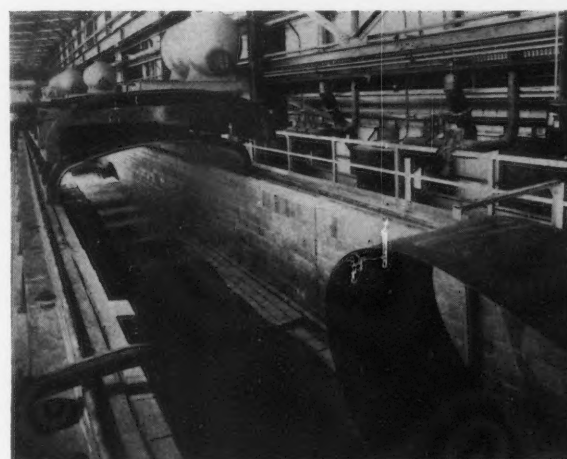


Figure 3—Part of a continuous strip pickling process showing a 60-foot rubber lined steel tank protected by brick joined with a phenolic resin cement and operating at 230 degrees F in the presence of 25 percent sulfuric acid.

Current Requirements For the Cathodic Protection of Steel In Dilute Aqueous Solutions*

By G. R. KEHN* and E. J. WILHELM**

Introduction

ANY METHOD of corrosion prevention which shows promise of being cheap, simple and effective is automatically subjected to widespread investigation and discussion. Such has been and still is the case with cathodic protection. This relatively new use of electric current now has an extensive theoretical background^{1,2,3,4,5} which explains that the function of current from an auxiliary anode is to cause polarization of the metal needing protection. Corrosion is halted when sufficient current flows to the metal to give it an equipotential surface. The wiping out of potential differences on the metallic surface is necessarily paralleled by a disappearance of local corrosion currents; these are the currents causing a dissolution of the metal in the anodic areas from which they flow.

While cathodic protection is theoretically on a sound basis, practical problems still exist. The two major questions are how to determine the current necessary for protection and how to distribute the current so that each portion of a structure will receive at least the minimum needed to prevent corrosion. The determination of the minimum current density required for protection assumes first place in any design sequence, but unfortunately, a search of the literature reveals no simple direct method which measures the actual corrosion rate during the evaluation of this minimum current density. The development of a suitable direct method is vital if cathodic protection is to be both complete and economical.

This article presents a direct method for determining the minimum current density required for protection. Specifically, it deals with the protection of steel against the corrosive action of solutions of sodium sulfate and sodium chloride, each solution having a concentration of dissolved salts approximating that of hard water. Impressed current was used as the means for polarizing the surface under investigation.

Four means are now available for minimum current density determination: 1) Rule of thumb, 2) Weight loss of metal, 3) Britton curve,⁶ and 4) Colorimetric analysis of a solution containing the corroded metal.

Abstract

A laboratory method, based upon colorimetric analysis, is described for finding the minimum current density required to cathodically protect steel against corrosion by water containing a small amount of dissolved salts. The minimum current densities determined by this method are compared with those obtained from a Britton curve for each of the two test solutions of sodium sulfate and sodium chloride. The significance of the minimum current densities determined by these two methods is discussed.

Rule of thumb gives a rapid approach which can be considered adequate in many instances, but it is certainly not always reliable. Weight loss and colorimetric analysis directly yield corrosion rates. From these rates it is possible to determine the minimum current required for protection. The Britton curve, however, relies on potential measurements to detect the point at which protection is just achieved.

Weight loss measurements are least sensitive in the current density range where greatest sensitivity is desired. This is true because the corrosion weight losses are reduced to very low values when the cathodic protection becomes appreciable. To obtain a measurable weight loss in this range of current density, a corrosion test must be run for a comparatively long time. During this long interval some of the corrosion product will tend to adhere tightly to the specimen. Removal of corrosion products of iron are difficult and can quite likely result in the removal of uncorroded metal. In such a situation a short time test is distinctly needed.

Indirect evidence of the point at which protection is just achieved is given by the Britton curve—a plot of cathode potential vs. the logarithm of the impressed current density. Complete protection is said to occur when the potential of the structure increases suddenly as the impressed current is increased gradually. Mears and Bialosky⁴ give an excellent review of this subject. They point out that the Britton curve is applicable to a special case, since it is based on corrosion occurring under cathodic control. Even so, the method has many features in its favor and is widely used, but to completely evaluate it, a check should be made by some direct method. This implies that the direct method should involve reliable measurements of actual corrosion rates.

Low corrosion rates can be measured rapidly by

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colorimetric analysis of the corrosion solution. Here is a means which, if properly utilized, should be sufficiently accurate for the required comparisons and is admirably suited to short-time corrosion tests.

In this investigation the thiocyanate method for the colorimetric analysis of ferric ion in solution was used. It is reported capable of detecting one part of iron in fifty million parts of water.⁷

Once the colorimetric method was set up, its results were compared with those obtained from Britton curves for the same two solutions. The object was to see if a reliable value for the minimum current density could be obtained from such curves. A relation would be valuable because of the inherent rapidity and ease involved in making potential measurements.

Description of Apparatus

A most important consideration in making corrosion tests involving cathodic protection is the maintenance of a uniform current distribution. Uniform current flow was attained in this work by using a cylindrical specimen as the cathode and a concentric graphite rod as the anode. Details of the corrosion test cell are shown in Figure 1. Three cells were used to facilitate gathering of data. Each cell consisted of a 3-inch steel pipe, 4 inches high, as the cathode, with a pipe cap screwed on the one threaded end. All cell bodies were cut from the same length of pipe. This pipe size was selected to assure a measurable corrosion loss and to allow a convenient volume of solution to be handled in subsequent operations. A special low-melting electrical insulating material, called Unichrome No. 316,* was used to coat the inside surface of the pipe at the top of the cell for a distance of approximately one inch. The solution in the cell terminated on the insulating material in order to eliminate any special water-line attack.

After pickling the inside surface to remove mill scale, more insulating material was melted and poured into the pipe cap until the uncoated metallic surface of the cell was about two and one-half inches high. Centering of the $\frac{5}{8}$ -inch graphite rod used for the anode was accomplished by making concentric holes in both the cell bottom and in a circular wooden lid. The wooden cover also had two $\frac{5}{16}$ -inch holes on either side of the anode to give air free access to the stagnant solution.

Six-volt lead storage batteries provided a constant source of current for the corrosion tests. Separate test solutions of sodium sulfate and sodium chloride were provided, each with a concentration of 500 ppm. A Fisher electrophotometer was used for color comparison in all colorimetric analyses.

Equipment for the Britton curve determinations was essentially the same as for the colorimetric investigation with the exception of a saturated calomel reference electrode and a potentiometer. A special tip of capillary tubing extended three and one-half inches from the bottom of the calomel electrode unit in order to establish contact with the cell wall. Agar gel saturated with potassium chloride was the conducting medium through the tubing.

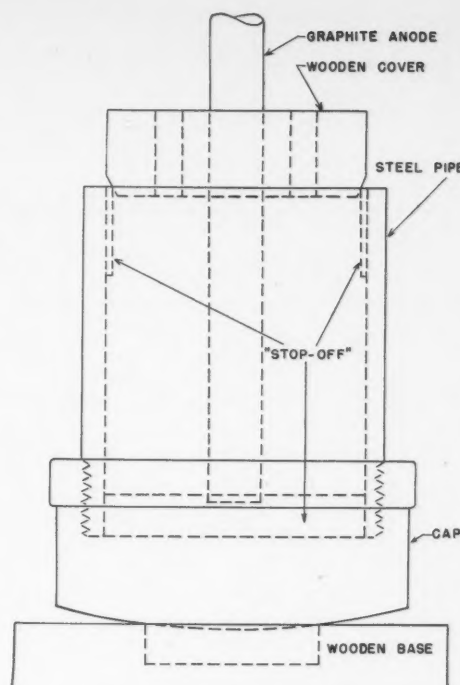


Figure 1—Corrosion test cell.

Procedure

Rust formed during the tests was dissolved by heating the solution after a small addition of concentrated sulfuric acid. Rust from short-time exposure is principally ferrous hydroxide, $\text{Fe}(\text{OH})_2$, and the ferrous ion must be oxidized to the ferric state before the chosen analytical procedure can be applied. Potassium permanganate was employed as the oxidizing agent. Formation of ferric sulfocyanate, the red-colored detector compound, was accomplished by addition of a saturated solution of ammonium thiocyanate, NH_4CNS , to the solution containing the ferric ion from the corroded metal. Objections to the use of potassium permanganate were considered, but the adopted procedure allowed no error from this source.

Standard iron solutions for comparison of color were made from ferrous ammonium sulfate, $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ (99.97% purity), a primary standard in quantitative analysis, and a calibration curve was made for the logarithmic scale of the photometer. The same calibration curve was used for the iron analysis of both test solutions although the curve was prepared for the sodium sulfate solution. The curve was used after a correction had been made based upon a sodium chloride blank.

Because all of the standard and unknown solutions had to be treated in exactly the same manner, a basic initial volume of 350 ml of corrosive solution was used in all tests. The surface of this volume of liquid terminated on the insulating coating at the top of each cell.

From preliminary experiments it was determined that a current of 3 ma was more than sufficient for keeping the inner surface of each cell free from rust.

* United Chromium, Inc.

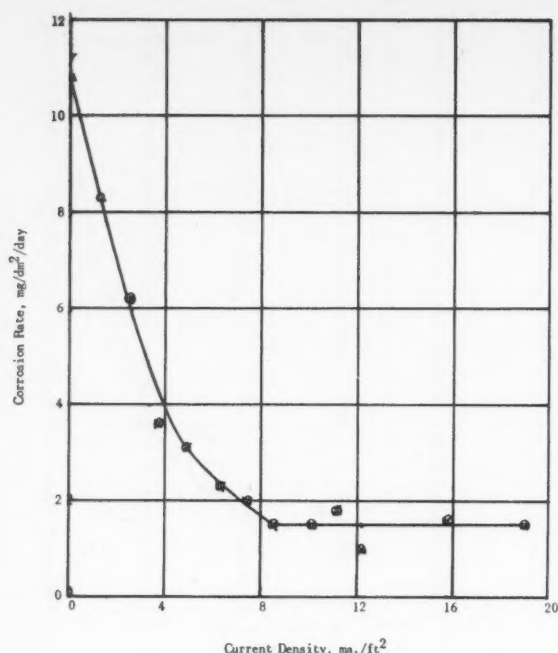


Figure 2—Determination of minimum current density required for protection of steel against water containing 500 ppm of sodium sulfate.

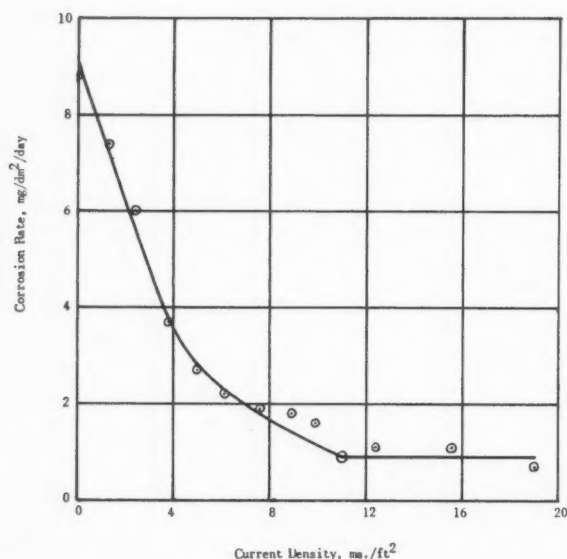


Figure 3—Determination of minimum current density required for protection of steel against water containing 500 ppm of sodium chloride.

Accordingly, this was the greatest current used in the investigation. Preliminary work also established the amounts of reagents required in the analytical procedure.

For each test at a particular current density, a cell was filled with the test solution, and a positive current of three or four ma impressed for at least two hours to loosen adherent rust. This was followed by a thorough scrubbing with a stiff nylon brush to insure clean walls at the beginning. A 350-ml portion

TABLE I
Effect of the Protecting Cathodic Current Density Upon the Corrosion of Steel in Water Containing 500 ppm. Sodium Sulfate.

Current ma.	Current Density ma./ft. ²	Ppm. Iron	Corrosion Rate mg/dm ² /Day
3.00	19.0	6.6	1.6
2.50	15.8	6.3	1.6
2.00	12.2	4.4	1.0
1.80	11.2	7.5	1.8
1.60	10.1	6.2	1.5
1.40	8.54	6.4	1.5
1.20	7.45	8.4	2.0
1.00	6.33	9.5	2.3
0.800	4.88	13.6	3.1
0.600	3.73	15.3	3.6
0.400	2.53	26.0	6.2
0.200	1.22	35.9	8.3
0.000	0.00	46.2	10.8

TABLE II
Effect of the Protecting Cathodic Current Density Upon the Corrosion of Steel in Water Containing 500 ppm. Sodium Chloride.

Current ma.	Current Density ma./ft. ²	Ppm. Iron	Corrosion Rate mg/dm ² /Day
3.00	19.0	3.0	0.7
2.50	15.5	4.0	1.1
2.00	12.4	4.4	1.0
1.80	11.0	4.0	0.9
1.60	9.94	6.8	1.6
1.40	8.86	7.6	1.8
1.20	7.60	7.8	1.9
1.00	6.10	9.5	2.2
0.800	4.97	11.6	2.7
0.600	3.80	15.4	3.7
0.400	2.44	26.0	6.0
0.200	1.27	31.1	7.4
0.000	0.00	38.3	8.8

of the test solution was then added, the anode centered, and the current adjusted to the desired value. Resistance of the circuit needed only slight adjustment during the first two hours; after that it remained constant and could be left overnight. At the end of 24 hours all of the test solution and the corrosion products resulting from the solution's contact with the metallic surface were collected in a beaker, 10 ml of concentrated sulfuric acid added, and the entire contents heated to boiling to dissolve the rust. After allowing the solution to cool, a few drops of 0.1% potassium permanganate were added until a faint pink color persisted. The entire solution was then transferred to a 500-ml volumetric and allowed to stand at least 24 hours to permit the color of the potassium permanganate to disappear.

To produce the red ferric sulfocyanate, 10 ml of the test solution was withdrawn from the volumetric, and 60 ml of distilled water was added along with 5 ml of ammonium thiocyanate. The purpose of the water was to reduce the color intensity of the sample. The colored solution was then placed in an absorption cell and a photometer reading taken after a fixed time interval, because the red color faded with time.

The concentration of iron, in parts per million, was read from the calibration curve, and the corrosion rate was calculated in milligrams per square decimeter per day, mg/dm²/day. Corrosion rate vs. current density was plotted for both solutions.

Simple potential measurements of the steel surface in contact with the corrosive medium were next undertaken in order to draw a Britton curve for each test solution. No attempt was made to correct the potential measurements for the IR drop through

TABLE III

Variation of Surface Potential with Current Density for Steel in Contact with Water Containing 500 ppm. Sodium Sulfate.

Current ma.	Current Density ma./ft. ²	Surface Potential Volts
3.00	19.0	-0.734
2.50	15.8	-0.710
2.00	12.7	-0.609
1.80	11.4	-0.544
1.60	9.75	-0.528
1.40	8.54	-0.512
1.20	7.32	-0.490
1.00	6.10	-0.473
0.800	4.97	-0.454
0.600	3.73	-0.471
0.400	2.48	-0.466
0.200	1.24	-0.460
0.000	0.00	-0.455

TABLE IV

Variation of Surface Potential with Current Density for Steel in Contact with Water Containing 500 ppm. Sodium Chloride.

Current ma.	Current Density ma./ft. ²	Surface Potential Volts
3.00	19.0	-0.774
2.50	15.2	-0.705
2.00	12.7	-0.607
1.80	11.4	-0.591
1.60	9.75	-0.539
1.40	8.54	-0.517
1.20	7.32	-0.495
1.00	6.10	-0.493
0.800	4.97	-0.472
0.600	3.73	-0.461
0.400	2.48	-0.455
0.200	1.24	-0.465
0.000	0.00	-0.463

the solution, though it was small because the tip of the calomel electrode touched the steel surface.

Each cell was placed in operation as described above. A preliminary test established a maximum time of two hours for a cell to reach equilibrium under the worst conditions. These were encountered with the sodium chloride solution at high current density. After two hours at each current density, a potential measurement was taken at one point on the cell wall. This process was repeated through the same range of current densities as were used for the colorimetric method. Each of the three cells was assigned one-third of the current density range; four single potential measurements, at successively decreasing current densities, were made with each cell. From this data Britton curves were prepared for the sodium sulfate and sodium chloride test solutions.

Experimental Results

Corrosion data for the sodium sulfate solution are summarized in Table I. In order to obtain the minimum current density required for protection of the steel against the sodium sulfate solution, the data from Table I were used for a plot of corrosion rate vs. current density. The resulting curve is shown in Figure 2. The current density at which the corrosion rate increased noticeably was taken as the minimum current density for protection. It was between 7.4 and 8.3 milliamperes per square foot, ma/ft.² This was confirmed by the visual observation of rust on the steel surface at 7.4 ma/ft.² and the absence of it at 8.3 ma/ft.²

A similar curve for the sodium chloride solution, taken from the corrosion data summarized in Table II, is shown in Figure 3. The minimum current density for protection was between 9.9 and 11.0

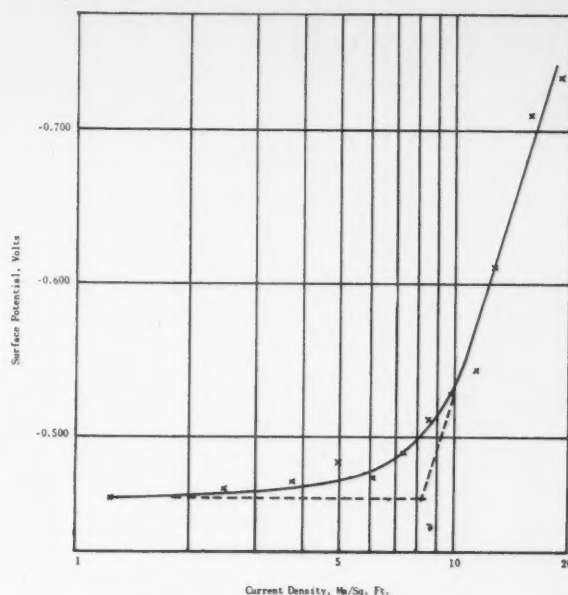


Figure 4—Britton Curve for steel in contact with water containing 500 ppm sodium sulfate.

ma/ft.² Again visual evidence of rust proved a good guide to the minimum current density required. Rust was apparent at 9.9 ma/ft.² and was absent at 11.0 ma/ft.²

A casual visual inspection of a cell wall did not always immediately reveal the presence of rust at values of current density near the minimum, but when the wall was rinsed with a small stream of water, the rust became very noticeable.

A comparison of the curves of Figures 2 and 3 shows that the chloride ion is more corrosive than the sulfate ion in that a higher current density is required for protection.

Potential measurements are summarized in Tables III and IV for sodium sulfate and sodium chloride respectively. The Britton curve for the water containing the sodium sulfate is shown in Figure 4. Extension of the straight-line portions of the curve shows that their point of intersection is at a current density of 8.2 ma/ft.² This is also taken to be the minimum current density required for protection. The reasoning behind this method is that, as the impressed current is increased from zero, the measured surface potential is that of the local anodic areas across the surface. In the meantime, the local cathodic areas are being polarized by the increasing impressed current until finally they reach the potential of the local anodes, which do not polarize. Any further increase in applied current will then cause the entire surface to act as the local cathodic areas were acting before. This results in a portion of the curve which represents the primary cathode reaction, the liberation of hydrogen. As the potential caused by the discharge of hydrogen has been found⁸ to vary linearly with the logarithm of current density, the straight-line portions represent the corrected curve on a semilogarithmic plot. The above reason-

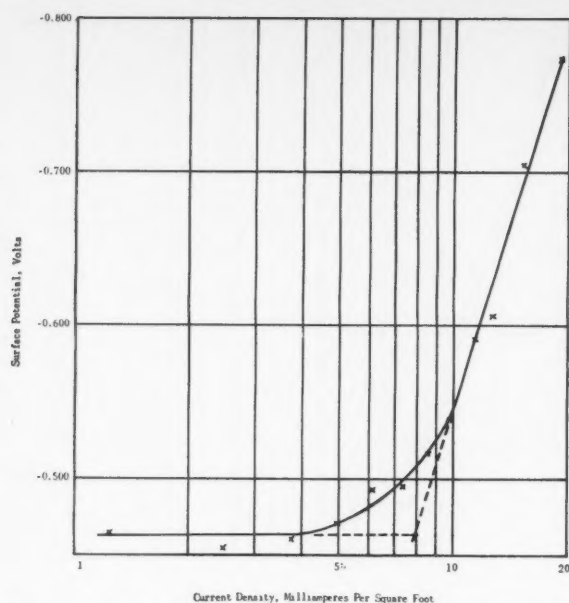


Figure 5—Britton Curve for steel in contact with water containing 500 ppm of sodium chloride.

ing holds true only if the specimen is corroding under cathodic control.

The close agreement with the colorimetric method indicates the Britton curve based on potential measurements is a suitable method for finding the minimum current density required for protection of steel against water containing a small amount of sodium sulfate. The results also show the importance of extrapolating the two straight-line portions of the curve to find the true point of sudden departure from the normal local potentials.

Data from Table IV were used to plot the Britton curve shown in Figure 5 for sodium chloride. The two straight-line portions of the curve intersect at a current density of 7.9 ma/ft.² This was much lower than the 11.0 ma/ft.² found by the colorimetric corrosion test and is similar to the value of 8.2 ma/ft.² found from Figure 4.

The similarity between the minimum current densities found for the two solutions by the potential method may be explained by the fact that the solutions had similar resistivities, pH values, and hydrogen discharge potentials. If any two salt solutions have the same resistivity and hydrogen discharge potential, then the current density and the corresponding potential at which the liberation of hydrogen begins will be the same for the two solutions. The important point is that the corrosive action of one of the dissolved salts may differ entirely from that of the other, even though the minimum current densities determined from the Britton curves are equal. In such a case the minimum current density determined from potential measurements is not a safe criterion for protection.

Summary

A laboratory corrosion test for cathodic protection, based on colorimetric analysis, was developed. The

method permitted a direct evaluation of the minimum current density required to cathodically protect steel and gave the corrosion rate of steel at various current densities.

The corrosion tests were easily carried out once the equipment and reagents were prepared; however, the lengthy preparations make this method most suitable for investigative purposes involving a large number of corrosion tests, or as a standard to compare with other more rapid methods.

Corrosion rates found in this investigation were in a higher range than those reported by Mears and Bialosky⁴ and Pallo⁹ for comparable tests. In the previously reported tests, a sample was withdrawn from the corrosion cell and analyzed for iron, whereas in this investigation all corrosion products were removed and dissolved in the solution before it was analyzed.

A simple visual examination for the first appearance of corrosion products on the surface of the steel was as accurate as the colorimetric method for finding the minimum current density, but it gave no information as to the rate the steel was corroding.

Steel in contact with water containing chloride ions required a higher minimum current density for cathodic protection than when in contact with water containing sulfate ions, even though there was no significant difference in the corrosion rates caused by these two very dilute solutions.

The method of potential measurements gave well defined Britton curves for the two test solutions. With the chloride solution the potential break occurred at a current density lower than that found from the colorimetric corrosion test. This result was in agreement with a previous observation by Mears and Bialosky⁴ that the potential method gives low results for steel when compared with a corrosion test based upon colorimetric methods.

The results of this investigation indicated that at best the potential method gave only an approximate indication of the true minimum current density required for cathodic protection and showed this indication may be lower than the true minimum.

Although no difference existed in the minimum current density as determined by the Britton curve and by the direct corrosion test in the case of the water containing sodium sulfate, there is reason to believe that a difference of other factors, such as pH and dissolved oxygen may destroy this agreement. These factors may not exert the same effect upon the cathode potential and corresponding current density as they do upon the rate of corrosion.

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Corrosion Problems Related to Air Transport Aircraft*

By O. E. KIRCHNER and F. M. MORRIS

Introduction

CORROSION PROBELMS in aircraft are associated with a wide range of metals and their alloys such as aluminum, copper, nickel, magnesium, low carbon steel, low alloy steel and stainless steel, etc., as well as cadmium, zinc, tin and chromium plated parts. It is necessary to have an electrolyte (conducting solution) present to have corrosion. Dry metal does not corrode.

Corrosion difficulties in aircraft may be attributed mainly to the following:

1. Exhaust gases and deposits containing lead bromide and free bromide which are caused by the combustion of leaded fuels in engines and gasoline heaters.
2. Spillage of food, fruit juices, and other liquids around buffet areas.
3. Leakage and splashes of liquids in lavatory areas.
4. Improper heat treatment of 17S, 24S and 75S aluminum alloys so maximum corrosion resistance is not developed.
5. Atmospheric and soil conditions such as dirt, dust, soot, chemical fumes in industrial areas, moisture (rain, snow, fog, condensation, highly humid areas), salt air of the seas and adjoining areas.
6. Improper or infrequent cleaning.
7. Improper or insufficient protective surface treatment and paint coatings.
8. Use of water containing high chlorides and sulfates in drinking and waste water systems.
9. Poor selection of metals to combat corrosive conditions encountered in service.
10. Miscellaneous.

Purpose

It is the purpose of this paper to describe the corrosion problems related to air transport aircraft, their causes and treatment, and prevention of such corrosion by proper design, maintenance of surface treatments and coatings, and cleaning operations.

Selection of Metal and Protective Treatments

Good design dictates the selection of metals which possess corrosion resistance to the fluids, gases, soils, etc. encountered in service operation, avoidance of pockets to collect moisture and use of absorbent corrosive materials in contact with metal that accelerate

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Abstract

Individual part protection is being adopted on aircraft superseding older methods of final overhaul in which coatings were applied after assembly and installation.

Special attention is given to aluminum alloy structure design to eliminate moisture collecting depressions and areas.

Electrical battery installations pose special problems. Control cables passing through pressure bulkheads wear off corrosion protection. Effect of exhaust gases on structure is well understood. Food buffets are a major problem because of food and liquid spillage. Protection from lavatory and wash water corrosion is not completely satisfactory.

Magnesium in power plants causes problems and undrained low spots corrode. Dissimilar metals in engines must be studied for corrosive effects. Radiators, feed valves, ignition systems and injectors need watching on this score.

The trend to steel propellers requires added steps in overhaul to protect abraded leading edges. Moisture under deicer boots must be watched. Improper heat treatment results in intergranular corrosion.

Varied sources of water used on aircraft necessitates careful placement of ground station filters, softeners, demineralizers or stills.

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corrosion, elimination of dissimilar metal contacts where moisture or fluids will be present to act as an electrolyte and accelerate corrosion, or proper insulation of such contacts; and also provision of easy access for examination and cleaning of areas subject to engine exhaust gases, food, lavatory and battery acid spillages. Good welding and fabricating procedures are essential, i.e., stress relief and removal of lead or zinc metal from Type 347 or 321 stainless steel exhaust stacks after forming operations, to obtain maximum life of parts in service. It is of fundamental importance that such aluminum alloys as A17S, 17S, 24S and 75S receive proper heat treatment and cold water quenching in order to develop maximum corrosion resistance and freedom from susceptibility to intergranular corrosion.

Typical protective treatments and coatings for

TABLE I
PROTECTIVE COATINGS FOR

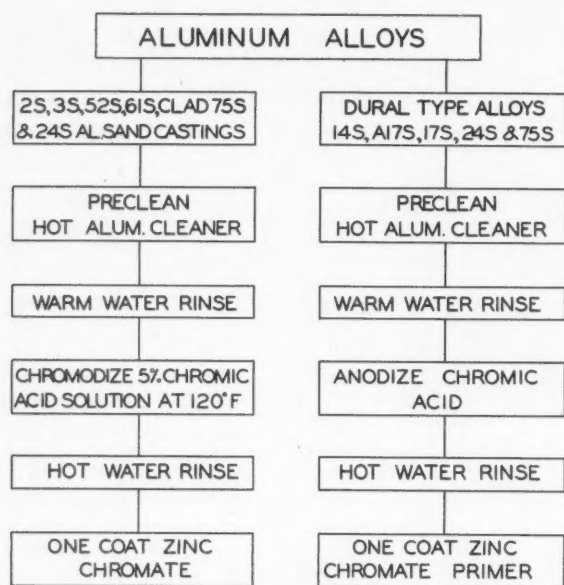


TABLE II
PROTECTIVE COATINGS FOR

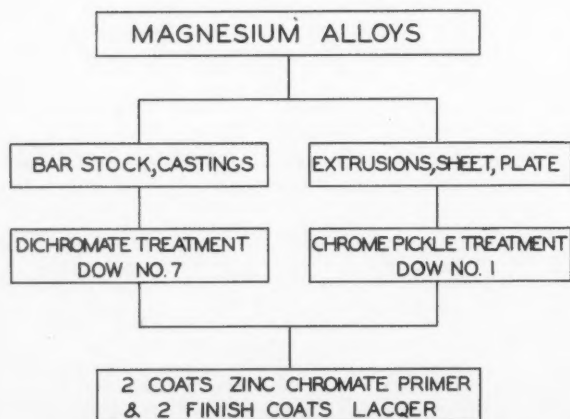


TABLE III
PROTECTIVE COATINGS FOR

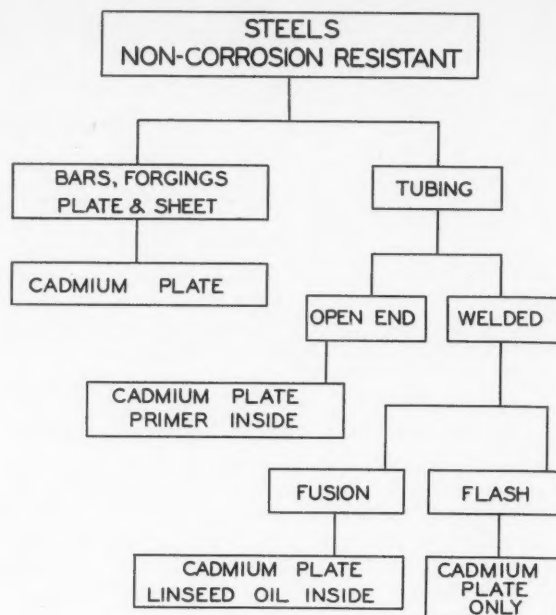


TABLE IV
PROTECTIVE TREATMENT FOR

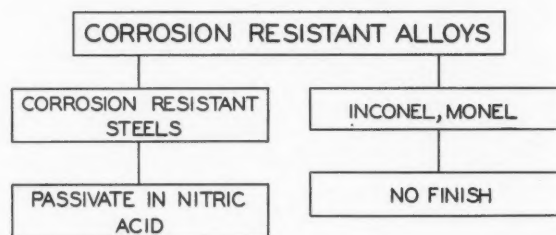


TABLE V
PROTECTIVE COATINGS FOR

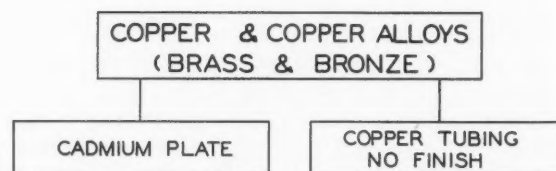


TABLE VI
FINISH FOR
FABRIC CONTROL SURFACES

1. ONE COAT MILDEW RESISTANT PRIMER.
2. FOUR COATS CLEAR CELLULOSE ACETATE BUTYRATE DOPE.
3. TWO COATS PIGMENTED CELLULOSE ACETATE BUTYRATE DOPE

aluminum alloys, magnesium alloys, steel, corrosion resistant steels, copper alloys, fabric and wood are shown in Tables 1 to 7. Surface treatments and primer coats are applied in detail before assembly.

Certain areas or parts subject to liquids, spillages of foods, and acid, and exhaust gases are given special coatings as follows:

1. Buffet and toilet areas including floors and portions of fuselage underneath—one coat zinc chromate primer and two coats acid- and alkali-resistant lacquer.
2. Battery compartments—one coat zinc chromate primer and two coats of acid- and alkali-resistant lacquer.
3. Flap gap, nacelle fillet areas, and portions of fuselage subject to engine or heater exhaust gases—one coat zinc chromate primer and two coats of aluminized lacquer.
4. Aluminum alloy fuel tank bottoms and sides—anodize in chromic acid.
5. Aluminum alcohol tanks—Alrok treatment inside.
6. Aluminum alloy lines in engine water injection system—Alodine treatment inside.
7. Aluminum water tanks—Alrok and phenolic coating inside.
8. Landing gear struts—chrome plate.
9. Control cables—coated with Paralketone rust preventive compound.
10. Gray chrome plated steel propeller blades—clear coat Quaker TM-2724 rust preventive compound.

Exhaust Deposit Corrosion

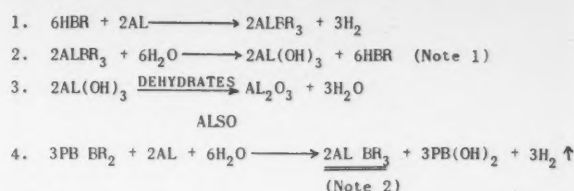
Aluminum

Exhaust gases and deposits contain lead bromide and free bromide as a result of the combustion of leaded fuels. The equations for the reaction of lead bromide and free bromide with aluminum are shown in Figure 1. It will be noted the products of corrosion first formed, i.e., aluminum bromide, are unstable and break down to form other corrosive products. This is the reason it is so important to remove the products of corrosion and passivate such areas with sodium bichromate solution. Significant corrosion of unprotected 24ST and 75ST clad aluminum alloys on wings has been observed within a period of two weeks when exhaust deposits were not removed.

Wing De-Icing Heating

De-icing of aircraft wing and tail surfaces under atmospheric icing conditions has, in the past, been achieved by breaking away the ice with rubber ex-

REACTIONS - EXHAUST GAS CORROSION



Note 1 - Observe that more HBR is formed to start the cycle again per equation 1.

Note 2 - Note that this product can in the presence of moisture start a new cycle per equation 2.

Figure 1



Figure 2—Nose heater exhaust stain on DC-4 airplane.

pander boots. Modern equipment performs this function by heating the wing and tail surface leading edges. The method used so far to make this heat has been gasoline combustion heaters similar in type to the conventional automotive Stewart-Warner type in which air is forced over hot surfaces. The second method consists of a system of mixing air with the engine combustion exhaust.

Initially in using air mixed with engine exhaust, it was felt that sufficient protection could be given to the wing and tail structures to protect against the corrosive elements in engine exhaust. Airline operators had their doubts about this since there was considerable background experience with the DC-3 model in which exhaust gases had a habit of getting into wing flap wells and interiors with considerable resultant corrosion.

After the airplane model in question was in service a very short time, the worst fears of the operators were confirmed. Since then, all the wing panels which have had this type of service have been replaced. At present, the heated air to the wing or tail surface ducts passes through a heat exchanger. In this manner, the air for this purpose never comes in contact with the exhaust gases. The protection of aluminum alloy structures from the effects of the products of combustion of exhaust is very difficult, especially when these gases are exposed to surfaces which are extremely inaccessible for cleaning and inspection. In addition to the normal products of combustion, free

TABLE VII
FINISH FOR

WOOD INTERIORS
ONE COAT FILLER & STAIN FOUR COATS CLEAR LACQUER



Figure 3—Nose heater exhaust track after coating with primer and aluminized varnish.



Figure 4—R-2800 combustion exhaust stack. Arrows point to intergranular corrosion along entire border of weld seam.

bromide and bromide of lead is liberated from the anti-detonation elements added to the fuel.

Nose Heater Exhaust Gases

During World War II gasoline combustion heaters came into general use in new aircraft designs. These heaters were primarily used for cabin and cockpit heating.

The combustion exhaust gases exit on the sides of the fuselage of the aircraft. It may be assumed that due to the high air flows that no problem would exist with reference to the release of these gases. This is not entirely true. Adjacent to the side of the fuselage, there is a dormant layer of air at practically zero velocity commonly called in aviation circles "the boundary layer." It is appreciable in thickness. That is one reason why one observes water droplets on the outside of cabin windows run downward across the surface in spite of the fact that the plane may be traveling at 300 miles an hour.

The products of combustion, when leaving the airplane, have an opportunity to come to rest on the aircraft Alclad 24ST skin surfaces as shown in Figure 2. One method of reducing this effect is extending into the air stream the opening of the outlet. But even with this arrangement the fuselage skin becomes affected. Directly at the opening, for protection from very hot gases, the immediate area is lined with stainless steel. The result of impingement of gases on the sides of the fuselage is to cause staining and corrosion in the form of bad pitting. The trouble in this case lies in the great amount of servicing required to keep the affected areas clean. The operation of cleaning in itself gradually causes a wearing away of the clad-

ding on the thin skin metal. In order to reduce the corrosion and also servicing, a fan shaped area, with the apex at the exhaust outlet, and extending backward for eight feet, was covered with zinc chromate primer and aluminized varnish as shown in Figure 3.

The basic cause of the problem still exists but its severity has been reduced resulting in considerable improvement of the appearance of this part of the airplane.

Power Plant Exhaust Stacks

Not so long ago, it was noticed that the power plant carburetors shifted in their metering characteristics as time accumulated on an engine after overhaul. At the same time, a build-up of deposits of foreign matter in the air passages of these units was noticed. Chemical analysis revealed a high percentage of stainless steel oxide. It could not be connected with any particular operation, or airport, or area or country, and it was finally determined that the oxide was coming from the power plant installation itself. The trouble finally was traced to external scaling of the engine combustion exhaust stacks. Normally, the aircraft engine obtains its combustion air by means of an external scoop which is located on top of the engine compartment in some installations and just inside the cowl on others. There are cases, however, when it becomes desirable to use warm air, for example, under engine atmospheric icing conditions. Under these operating conditions, the scoop air source is cut-off and all air comes from the engine compartment, and it is that air which passes through and between the cylinder barrels and fins. It was found that the air in its heat pick-up also accumulated a certain amount of exhaust stack oxide dust which lodged in the carburetor bleed lines. In order to avoid some of this difficulty and principally to obtain greater life, consideration was given to the use of 19-9DL stainless steel for stack material, as it could operate at higher temperatures.

At overhaul, the stacks were sand-blasted and pickled prior to re-use in a 5 percent hydrofluoric-12 percent nitric acid solution. Serious intergranular corrosion condition along the edges of the weld line was observed after the pickling process was instituted as shown in Figure 4. This condition was noted only on the 19-9DL and not on the Type 347 stainless steel stacks. Since there was considerable concern about the effect of this intergranular corrosion on the strength of such a vital part, it has been necessary to rely in the case of the 19-9DL stacks on sand blasting only. Further work is being undertaken to carry this study further.

DC-4 Flap Gap Areas

The flap gap Alclad 24ST skin forms the trailing edge of the wing just forward of the leading edge of the flap in the DC-4 airplane. In flight, when the flap is lowered for landing to increase the lift of the wing and reduce the airplane speed, exhaust gases from the engine pass between the trailing edge of the wing and the leading edge and deposits collect on the surfaces. Figure 5 shows a flap gap skin with particularly heavy corroded areas along and at the edges of the riveted seams. Figure 6 is a photo-micrograph

which illustrates a very unusual type of pitting corrosion at the outer edge of the joint. Ordinarily, when corrosion occurs on Alclad sheet, the coating is dissolved sacrificially and thus protects the core. The flap gap skin is inaccessible for routine cleaning without removal of the flap so such areas must be protected with one coat of zinc chromate and two coats of aluminized lacquer or varnish.

DC-6 Center Section Skin

The exhaust stack system of the DC-6 airplane is designed so that the combustion exhaust gases pass over the upper and lower portions of the center wing section.

When the DC-6 airplane was originally received

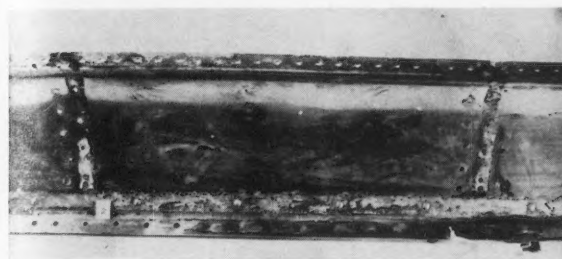


Figure 5—Corroded flap gap area.

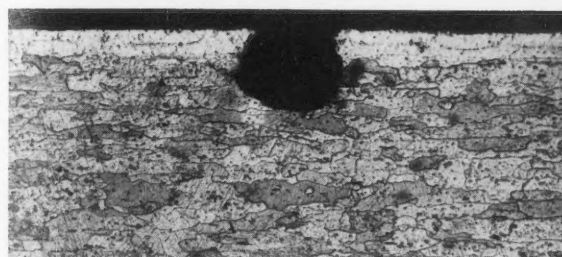


Figure 6—Shows nature of the attack in the sample from the flap gap. This attack was caused by some substance in the presence of which the normal potential relationship between the coating and the core of Alclad sheet did not hold. 100 X, Keller's etch.

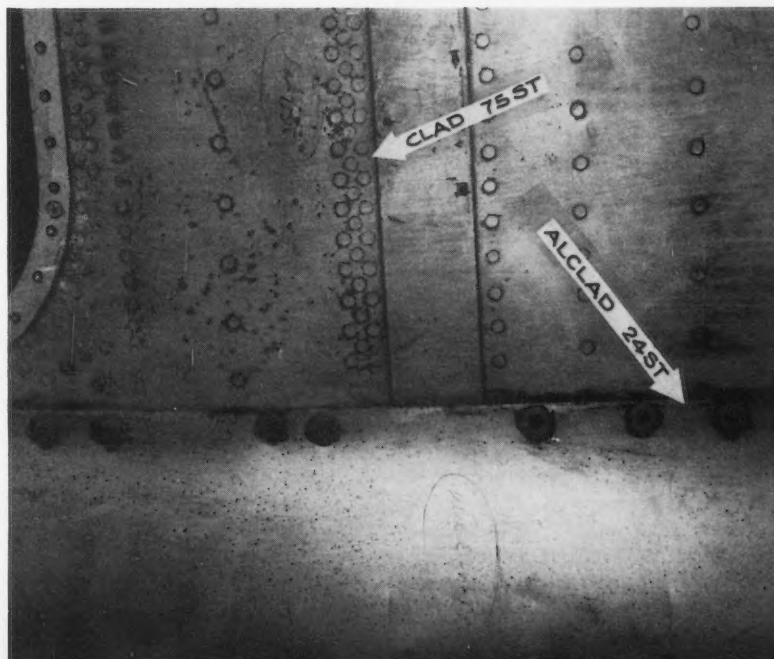


Figure 7—Corrosion of Alclad 24ST and 75ST skin on DC-6 center section due to exhaust deposits.

from the manufacturer, the center section exterior surfaces were painted with zinc chromate primer and aluminized duPont 1234 methacrylate type lacquer. Due to the vigorous scrubbing action to remove exhaust gases which became embedded in the finish the paint was removed in some areas and considerable expense was involved in repainting at each engine change. There was some question whether the paint was actually needed on the Alclad surfaces so the paint was stripped from the center section of one airplane, then operated for one year in order to determine whether regular cleaning procedures were sufficient and frequent enough to avoid corrosion due to exhaust deposits. During the service test for a period of one year, the surfaces were examined frequently for corrosion. Only incipient surface corrosion was observed which could be removed easily by



Figure 8—Corrosion underneath paint on DC-6 center section due to exhaust gases.

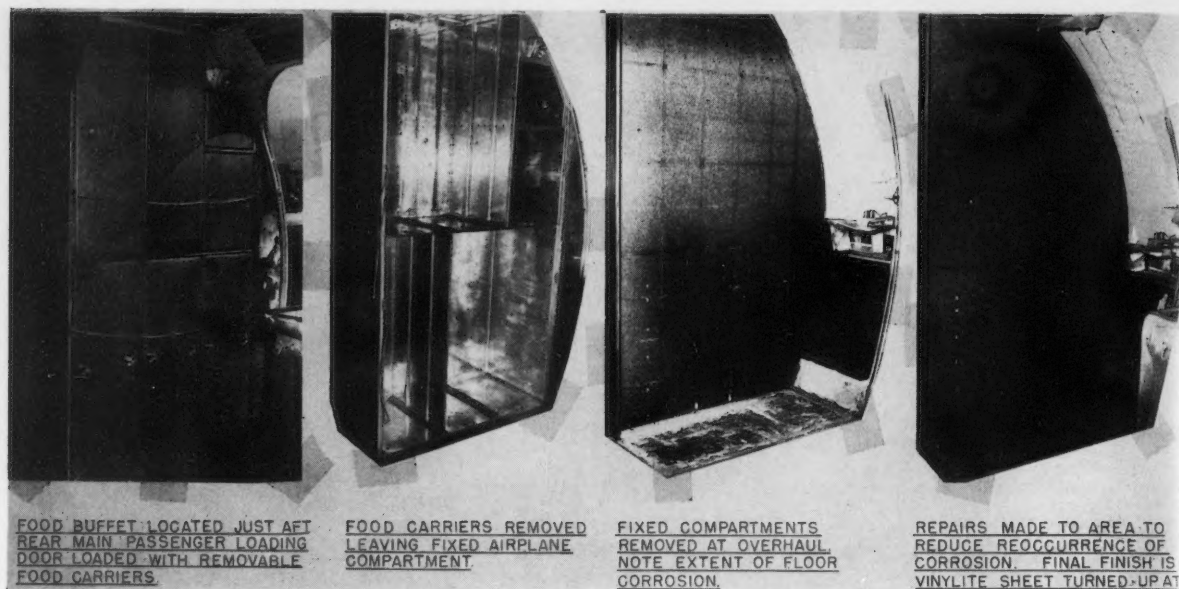


Figure 9—Douglas DC-6 aft food buffet.

a wipe with NuSteel Company's Alumi-Nu Polish No. 9, Type 5060 Liquid Polish. On the basis of this service test, the paint was removed entirely from the center section Alclad surfaces on the remainder of the airplanes. The flap gap area and magnesium slat were left in the painted condition.

Another airline with a fleet of DC-6 airplanes had operated them with the original type of paint on the center sections. This airline has experienced extensive corrosion of center section Alclad 24ST and clad 75ST skin as shown in Figure 7. Figure 8 shows evidence of corrosion around rivets through the paint. In this case, the paint coating has failed to prevent corrosion. This airline operator will clean exhaust deposits from the center sections more often and apply a better paint protective coating to areas subject to exhaust gases.

Corrosion from Food Spillage in Buffet Areas

DC-6 Food Buffet

This airplane model is equipped with a buffet installation suitable for handling meals for fifty-two passengers. All meals come on board the airplane already cooked and only need to be placed on a tray for serving by the stewardess. All meals are delivered to the airplane in suitable containers and these containers racked in the airplane. The buffet location is adjacent to the main loading door of the airplane. Rain, cleaning fluids and spilt food liquids end up on the floor and eventually reach areas under the food container racks. These liquids remain hidden and inaccessible and set up conditions ideal for corrosion. These areas are only accessible when the airplane comes in for overhaul and the food container racks are removed. To avoid recurrence of these corrosion areas when the airplane again goes out in service, all airplanes are given the following treatment:

- a. Thoroughly clean all floor areas.



Figure 10—Corrosion of Alclad 24ST flooring at passenger door of airplane.

- b. Patch all holes.
- c. Paint floor area with bituminous mastic acid-resistant paint.
- d. Cement vinyl covering in place and turn up at each edge, being careful to seal all edges.
- e. Replace food container racks.

Figure 9 shows corroded floor area under the buffet, and also after repairing, painting, vinyl covering cemented in place, the racks and food boxes installed.

DC-6 Passenger Door Entrance

Some corrosion of Alclad 24ST flooring has been observed under the stainless steel strip at the passenger door entrance and buffet of the DC-6 airplane as shown in Figure 10. Spilled liquids from the buffets and rain water, when the door is open, run under the metal strip. During engine change or overhaul, the products of corrosion are removed, the areas treated with sodium bichromate solution and then painted with zinc chromate primer and bituminous mastic acid-resistant paint.

Corrosion from Leaks and Splashes in Lavatory Areas

Wash Water and Lavatory Servicing Mechanism

Wash water and lavatory servicing have been elim-

inated from the cabins of modern air transport aircraft. Provisions for such servicing are now provided on the side of the aircraft fuselage accessible to servicemen on the ground. The advent of the pressurized cabin has made the requirements for outside servicing somewhat more difficult because of the need for preserving a pressure seal at the servicing panel.

Water tanks are filled and the lavatory hoppers are serviced by ground carts brought up to the airplane as shown in Figure 11. Special pumps and controls allow for discharge of the hoppers and also provide for a water rinse. All of the operations are planned to avoid any spillage on equipment or personnel during the servicing operation.

Although considerable thought has been given to this design for protection of the internal operating mechanisms, the proper sealing of shafts, valves, etc., corrosion does still occur. While at first it was thought that plated steel parts could be used, it has now been necessary to change these to stainless steel. Figure 12 shows the original cadmium plated valve shaft, screws and nuts which have rusted. The original design also used aluminum alloy, which was protected with zinc chromate primer and enamel top coats as the cover for the hopper. Considerable corrosion of this part has resulted from splashing of the hopper contents, etc. It is recommended that all parts required for the operation of an air transport lavatory of the modern type or located in the vicinity of the lavatory hopper be made of stainless steel.

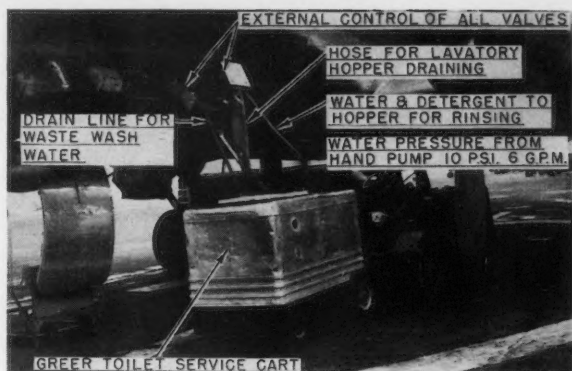


Figure 11—Greer Toilet service cart.

DC-4 Lavatory

A certain amount of splashing is experienced in the lavatory areas. Figure 13 shows an Alclad 24ST panel with zinc chromate primer which was installed behind a DC-4 lavatory in contact with an absorptive material. In this instance, improper protective coating and poor design, i.e., presence of absorptive material not sealed against liquid splash were contributing causes. Unless the absorptive material is thoroughly impregnated under pressure, the material acts as a wick and holds the moisture in contact with the metal, thus causing excessive corrosion. It is much better, in case a well impregnated material is not available, to apply one coat of zinc chromate primer

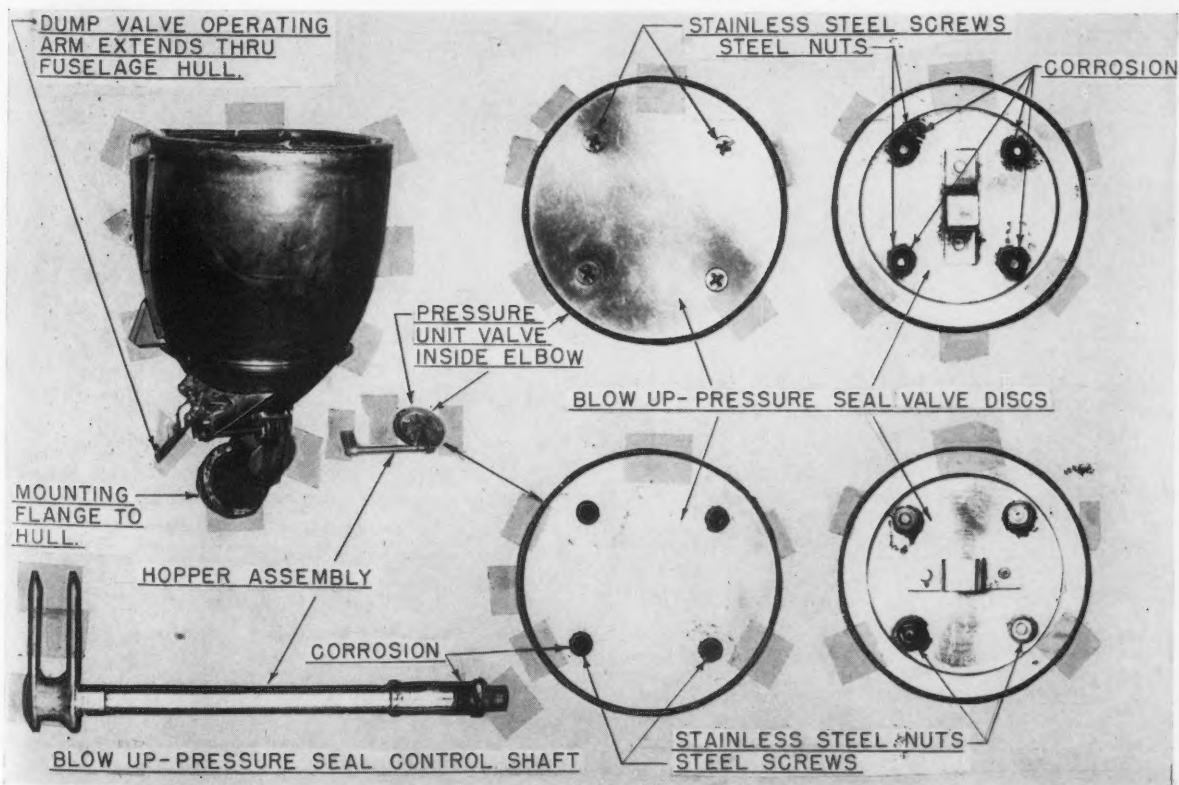


Figure 12—Douglas DC-6 toilet hopper.

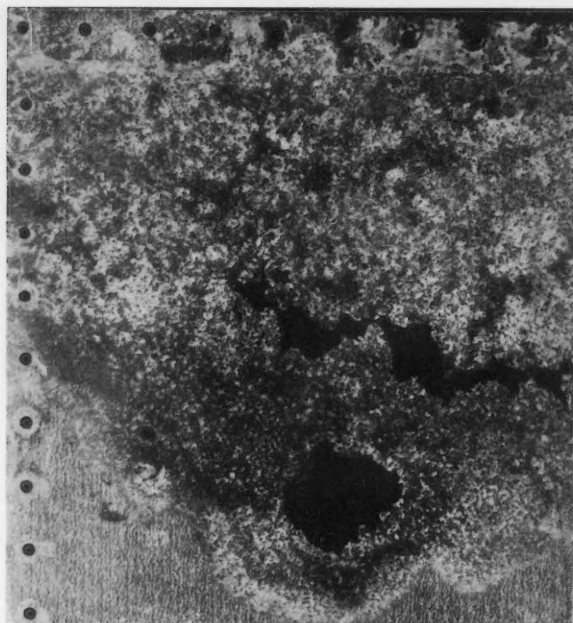


Figure 13—Corroded panel originally installed behind a DC-4 lavatory.

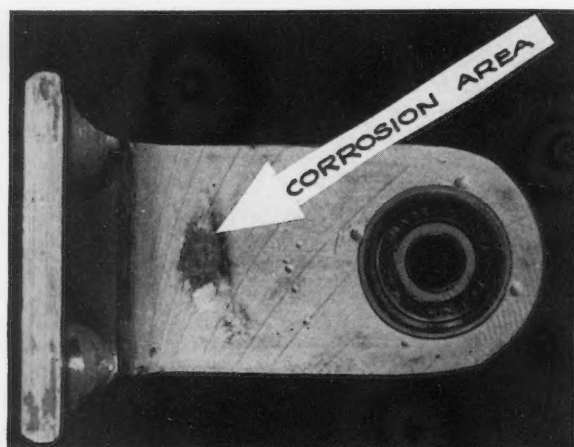


Figure 13-A—Exfoliation type of corrosive attack of 24ST aluminum alloy DC-4 rudder attach fitting for tab.

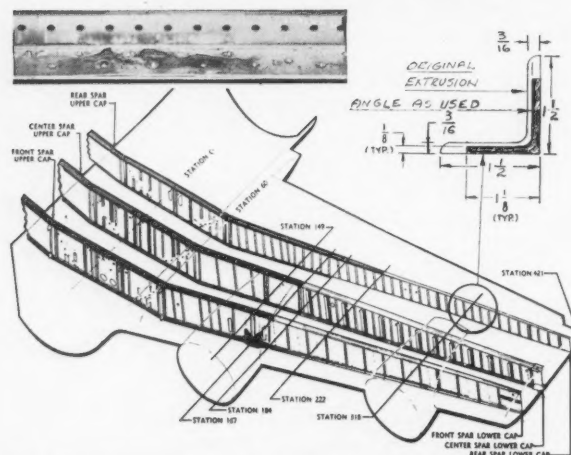


Figure 14—Intergranular corrosion 24ST extruded angle on rear spar of DC-4 airplane.

and two coats of aluminized alkali and acid resisting lacquer or varnish.

DC-6 Fuselage Skin Adjacent to Rear Toilet Valve

One of the toilet drain valves in the DC-6 sleeper airplane is located at the rear of the cabin on the lower side of the fuselage. Due to improper seating of the toilet drain valve, some leakage has been experienced. When the airplane is on the ground, the leaking liquid runs to the belly of the fuselage and, in flight, is then blown aft over a considerable area of the fuselage. As the liquid leaks from the valve in flight, it is blown aft along the side of the fuselage, into the access door at the tail end of the fuselage and into openings around the rear horizontal stabilizer where it is attached to the fuselage. Some corrosion has been noted along the fuselage, around the access door frame and under the horizontal stabilizer fairing. It has been necessary in such cases to remove the products of corrosion, thoroughly swab with a sodium bichromate solution and then paint with one coat of zinc chromate primer and two coats of aluminized nitrate lacquer or varnish.

DC-6 Lavatory Floors

Some corrosion of the lavatory floors in DC-6 airplanes originally occurred due to splashed liquids running along the edges and underneath the floor covering. This corrosion problem has been overcome by removing the old floor covering with sponge rubber back and cementing linoleum in place. The edges of the linoleum floor covering are turned up and sealed with cement against the entrance of liquids.

Corrosion from Improper Heat Treatment

There have been numerous cases of corrosion of a DC-4 24ST aluminum alloy rudder tab hinge support fitting after 3000 to 4000 hours of operation. Figure 13A shows exfoliation type of corrosive attack of such a fitting with its typical-blister-like formation. This fitting was machined from a 24ST tee section extrusion $\frac{3}{8}$ -inch thick to a final dimension of $\frac{1}{4}$ -inch and was protected with zinc chromate primer and two coats of lacquer. Rockwell hardness tests indicated the fitting exceeded the minimum tensile strength. Corrosion of the fitting is attributed to the slow quenching effect obtained in the original thick section in the heat treat operation which resulted in the poor corrosion resistance of the section after machining. The corrosion resistance of this fitting would have been improved, if re-heat treatment had been performed after machining. Another alternative would have been to use 14ST aluminum alloy which may be quenched in hot or cold water in the heat treat operation and still obtain good corrosion resistance. In all cases of exfoliation type corrosion, it is our practice to replace the part, since this type of corrosion can seriously reduce the strength of the metal.

DC-4 Rear Spar Extruded Angle

Occasionally, an off-color sample of 24ST aluminum alloy structural corrosion is found. In one case of an angle used in the fabrication of the rear spar of

one model aircraft, after 10,000 hours of airplane operation, a well developed case of intergranular corrosion was found as shown in Figure 14. The angle, as used, was one reworked from an extruded section originally $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$. The reworked angle measured $1\frac{1}{8} \times 1\frac{1}{8} \times \frac{1}{8}$. The exposed surfaces of this part were subject to the effects of water brought in by the wing flaps and a certain amount of engine exhaust coming from the power plant just ahead of this area. It is rather significant that this was an isolated instance and therefore it was decided that something in the nature of the material itself was the principal cause. It was our feeling that the original heat treatment of the extruded section was improper or that its effect did not carry through the metal in sufficient degree to provide the proper protection in the material in its reworked form. Proper and continued inspection is required to ferret out these weak cases. The only correction in such cases is replacement of the part.

Corrosion of the Fuselage Skin

Figure 15 shows corrosion of Alclad 24ST skin in a lap joint which was removed from the lower portion of a fuselage and is characteristic of oxygen-cell corrosion in such locations. Figure 16 is a photomicrograph of the cross section of the skin which shows relatively large precipitate particles due to slow quenching in the heat treating operation. This microstructural feature indicates that the material would have poor corrosion resistance.

Corrosion from Improper or Infrequent Cleaning

Engine Oil Coolers

With the beginning of operation of the Douglas DC-6 and Consolidated Convair airplanes, it was the airlines' first experience in the use of 61S aluminum tube engine oil coolers. As a corrosion protection, these tubes were given an Alrok treatment. The tubes were formed from soft aluminum material. Very early in the use of this equipment, the radiators began to give service trouble by leaking. A very thorough investigation was instituted which resulted in the findings as noted:

1. It was found that in the internal cleaning of these radiators or coolers which involved water, steam and proper cleaning solutions, insufficient attention had been given to removal of all moisture. An amendment to the process to finish up the cleaning with circulation of a rust preventive oil at 240° F. was made, which was sufficient to eliminate the moisture and coat the tubes for such storage time until the cooler became installed in a power unit. The time allowed is just enough to eliminate moisture bubbling from the circulating oil.
2. It was also found that insufficient instructions had been given to our Stores and Supply Department in the need for the proper handling of stock replacement tubes. The tubes originally were handled as so much loose parts and a stock bin would look like a bin of timber spikes. This loose handling resulted in scratched tube surfaces and re-



Figure 15—Corroded fuselage skin.

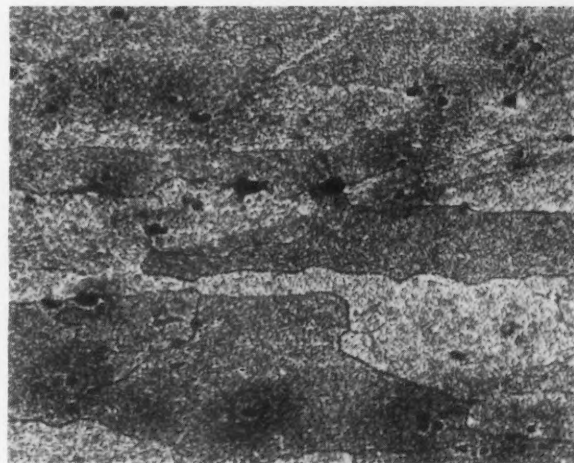


Figure 16—Shows extensive precipitation along grain boundaries and within the grains of the core portion of the Alclad doubler plate from the fuselage. Material either had been very slowly cooled from the heat treating temperature or had been reheated.

moval of Alrok treatment. The tube when installed was immediately susceptible to corrosive action in the presence of moisture. As soon as the seriousness of this condition was made known to those

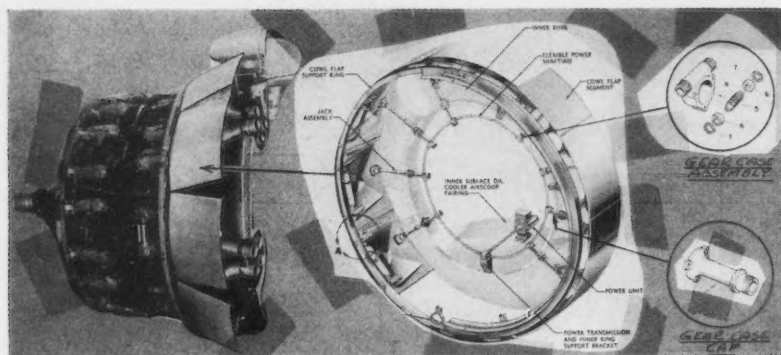


Figure 17—R-2800 cowl flap ring.

concerned, changes in handling technique aided in the correction of our leaking trouble. At the present time, our aluminum tube engine oil cooler is one of our most reliable pieces of aircraft equipment.

Corrosion Due to Atmospheric Conditions

Engine Cowl Flap Control System

Present aircraft engine cooling requirements are very critical and require proper handling and control of the engine compartment cooling flaps. These units, as shown in Figure 17, are located just aft of the engine proper and, by their position, determine the amount of cooling air which can flow from just behind the propeller through and between the cylinders and exit through the cowl flaps. There are eight flaps synchronized by a screw jack arrangement controlled from a master motor. Several parts of the screw jack mechanism use magnesium castings. Internal corrosion of these parts has been noticed. In this case, because Sinclair AF2EP grease was used to lubricate the screw jack parts in these castings, the difficulty was corrected by increasing the grease vol-

ume. This method was considered cheaper and simpler than working up a specific corrosion-treatment for the interior surfaces of these parts.

Engine Vibration Isolator

The aircraft engine and its attached components and accessories set up, as a consequence of its power impulses, very annoying vibration forces. Considerable advance has been made in the last few years towards insulating the airplane structure from these repetitive shocks. A development commonly called Dynafocal Suspension has been introduced which greatly reduces these effects. Previous practice in attempting to reduce vibration consisted of placing shock absorbing units where the engine mount attaches to the aircraft. With the Dynafocal arrangement, the mount is rigidly attached to the structure and the isolators installed between the conventional mount and engine case as shown in Figure 18. Their location is such as to be considerably nearer the center of gravity of the mass producing the impulse forces. This arrangement eliminates considerably large impulse moments which were difficult to control in early mounts. Considerable development has

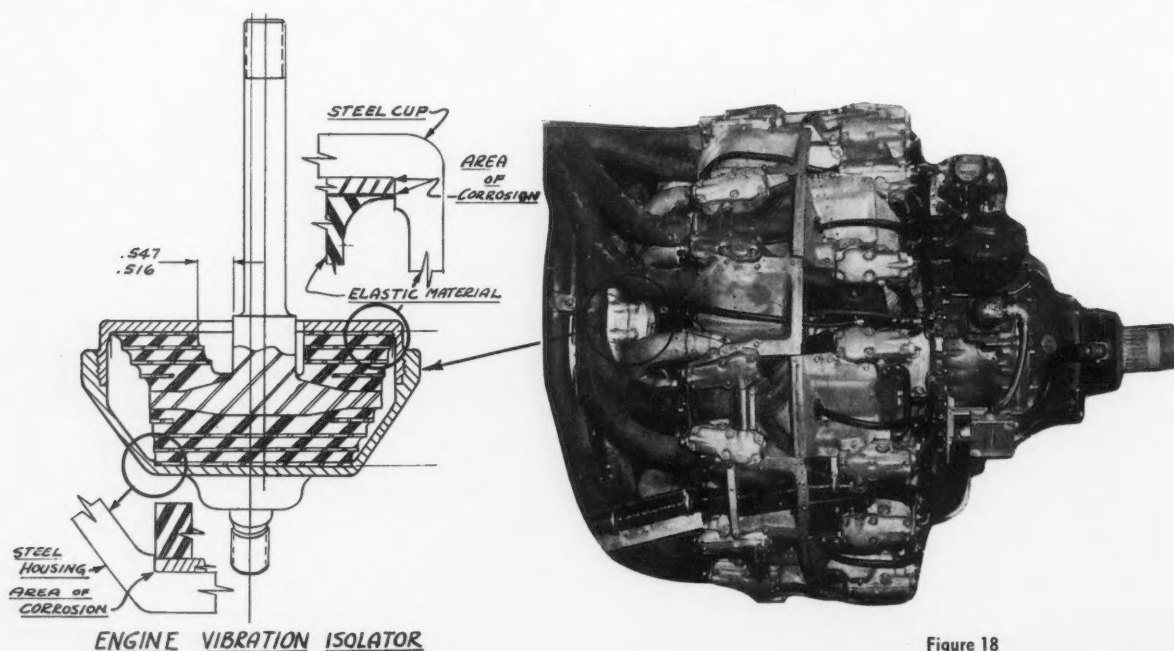


Figure 18

resulted in a Dynafocal suspension vibration isolator now used for that purpose. The isolator is principally a steel forging cup arrangement in which vulcanized elastic material is confined. The elastic material is a secret formula of the rubber family. These housings, although seemingly waterproof, do allow breathing to deposit moisture as a result of changing altitude. Corrosion has been noted, as illustrated in Figure 18, at those areas forming boundaries of the elastic material and the inner surfaces of the steel housings. Other exposed areas have not shown any corrosion effects. Six isolators are used per engine. Correction of this problem has been made by cadmium plating these parts at each engine overhaul period. It is probable that the electrolysis set up by the moisture, steel and corrosive elements in the elastic compound is the cause of this trouble. It was desirable to avoid this special corrosion treatment from an economical standpoint. Each extra step in the routing of the part, the extra demand on the plating shop, and the additional spares needed for the additional pipe line, all add an extra expense to the cost of operation.

Integral Fuel Tanks

Figure 19 shows slight corrosion of aluminum alloy corner fittings and A17ST rivets and also rusting of cadmium plated nuts and bolts on the interior of a DC-4 integral fuel tank after being in service for approximately 10,000 hours. Some corrosion has taken place despite the fact such parts were protected with a thick coating of Stoner-Mudge (Thiokol compound) with which the tanks were sealed. Although the direct cause of the corrosion is unknown, it may be surmised that moisture condensation in the gasoline combining with lead and bromine may have been contributing causes.

Isolated cases have been reported by other airline operators of extensive corrosion of the bottom plating as well as intergranular corrosion of extrusions necessitating expensive repairs in DC-4 integral fuel tanks.

After approximately three years of operation of DC-6 airplanes, there has been only one known case of corrosion in the integral fuel tanks. Figure 20 shows pits due to corrosion of a DC-6 bottom fuel tank access door of clad 75ST aluminum alloy. The exact cause of corrosion is unknown but it is suspected that foreign matter and condensation in contact with the metal resulted in electrolytic corrosion.

The seams in the DC-6 tanks have been sealed with Minnesota Mining & Manufacturing Company's EC-801 which is a Thiokol-type compound. The entire tank interior is coated by fill and drain method with EC-776, which is a clear Buna compound, for the primary purpose of preventing leaching of the plasticizer from the EC-801 by high aromatic content gasoline. However, the EC-776 is also resistant to water and would offer some protection to the metal.

Pratt & Whitney B-2800 Magnesium Rear Accessory Case (Part No. 84420)

This part is provided with an oil drain hole at one of its lowest sections. The drain plug assembly consists of a steel insert, PWA Part No. 20117, and steel



Figure 19—Corroded aluminum alloy corner fitting and rivets, and rusted nuts in DC-4 integral fuel tank.

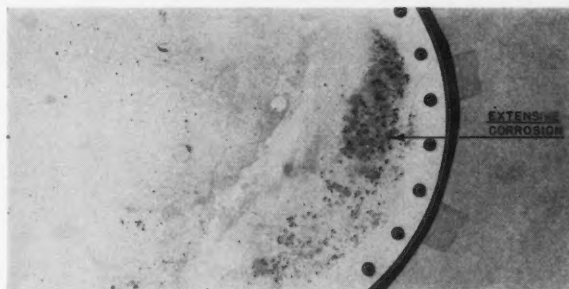


Figure 20—Fuel tank bottom access cover.

plug, PWA Part No. 20126. It happens that at this section there is very little washing effect of the circulating lubrication oil and water becomes trapped in this plug area. Various methods of corrosion protection have been applied to the plug and insert with very little protection resulting to the surrounding magnesium case. It has been considered that the insert installation procedure sufficiently affected the cadmium or other protection to bare the steel metal surfaces to the magnesium and water. The resulting galvanic action quickly corroded the magnesium as shown in Figure 21. Similar effects have been experienced with anodized Dural plugs. The final solution of this trouble was the use of EC-801 compound. EC-801 is a proprietary semi-fluid coating consisting essentially of Thiokol rubber which sets to a tough rubbery mass upon addition of EC-807 accelerator. Its low shrinkage and exceptional resistance to solvents make this sealer useful in many difficult locations.

The areas affected by corrosion are first thoroughly cleaned with 1/4-inch burring bits. Prior to application of the EC-801, the areas are given the Dow No. 1 chrome pickle treatment. Figure 21 also shows the case after treatment.

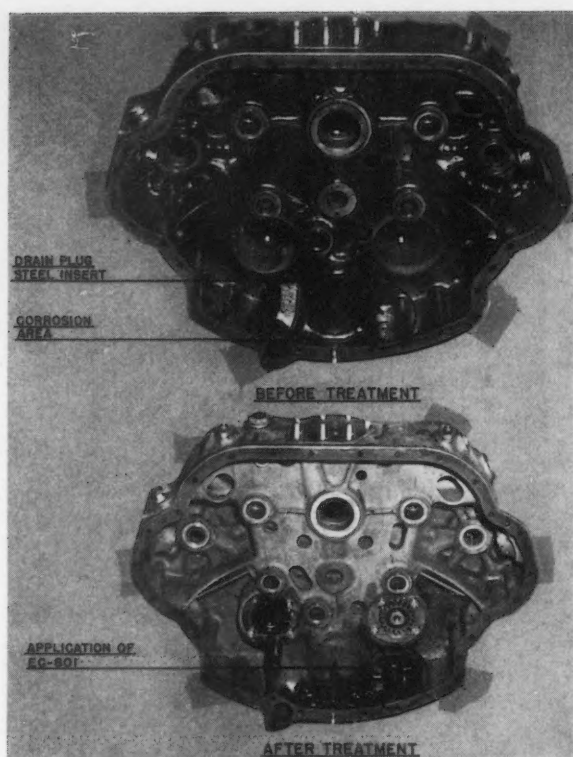


Figure 21—Aircraft engine rear accessory case.

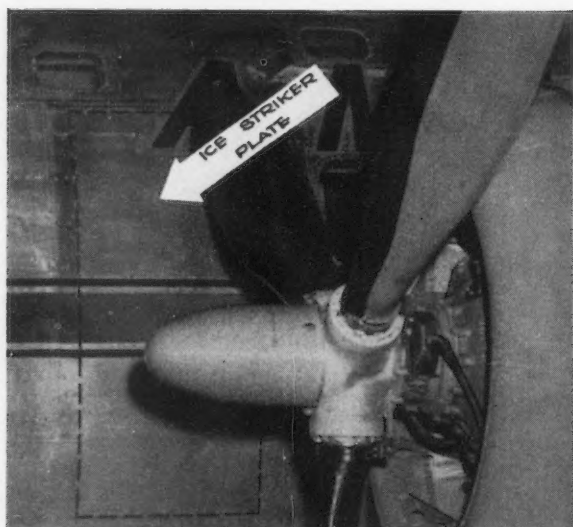


Figure 22—Ice striker plate installed on DC-6 airplane.

Internal Fuel Lines

Flying at high altitudes for long periods gives the structure opportunity to reach the atmospheric temperature existing along the flight path. This is especially true of the fuel remaining on board. A descent into warmer atmospheres usually is at such rates that condensation of the warmer moist atmosphere does not occur on the general structural part of the aircraft. With respect to the fuel system, this is not

necessarily so and the cold fuel flowing from the tanks to the power units keeps the lines at a temperature much lower than atmospheric.

Condensation, therefore, is prevalent on fuel lines, although they are located in the wing cells. Although this is not a serious problem periodic inspection of these lines is required to see that they are properly protected and corrosion gets no worse than a thin film of dust on the lower surface of the line as a result of the condensate dripping from them.

General Corrosion Protection—Hidden Surfaces

Present airplanes operate through an extensive atmospheric pressure range. Air transport aircraft now regularly fly at altitudes of 25,000 feet above sea-level. This altitude corresponds to an atmospheric pressure of 5.4 pounds per square inch. Sea level pressure is 14.7 pounds per square inch, resulting in a pressure differential of 9.3 pounds per square inch. This pressure differential is sufficient to produce a considerable amount of breathing between large surfaces laid together.

Unless the matching surfaces are very thoroughly individually protected or the spaces completely filled with some non-corrosive material, moisture will be brought in and settle to eventually cause corrosion. One of the most notable examples which illustrates this problem is the use of ice striker plates mounted on the side of aircraft fuselages and located in the propeller plane. The ice striker plate is used to give additional local material stiffness to resist the impact of ice particles thrown off the propeller tips under atmospheric icing conditions. It is rather difficult to obtain a good surface-to-surface contact because of the large surfaces involved.

To overcome possible air pockets between such large surfaces, it was thought as first that a properly impregnated canvas duck would act as such a filler. For such a canvas filler to be effective, it was necessary that the duck be dipped to assure that all fibers would be covered. It was soon found that, in spite of good control in the preparation of the duck material, a certain amount of wicking of moisture continued to accrue with resulting corrosion. Corrective measures in this case consisted of removal of the ducting and the application of an acid-proof lacquer over a coat of zinc chromate primer applied to both the fuselage skin and ice striker plate. To assist in the removal of this plate for inspection and replacement purposes, it is held in place with screws rather than rivets. Figure 22 shows the ice striker plate installed on a DC-6 airplane. Our experience to date indicates that this fix is working out very satisfactorily.

Instruments

Manufacturers efforts to design lighter and lighter instruments have been changing to the use of aluminum for mechanism supports, etc., in building their instruments. This has not been as satisfactory as might be expected, especially if any possibility exists that moisture may be present. The continual breathing of this equipment as the aircraft changes altitude is sufficient to cause moisture deposits to be accumulated and result in corrosion, as shown in Figure 23.

In order to overcome some of this difficulty, instrument manufacturers have provided tight covers over such aluminum parts with little success. The correction lies in the use of anodized parts, but this protection is rather difficult to apply in assembled parts of this nature. Until a basic change can be made in the instrument, correction in the nature of cleaning of the parts is all that is left to be done. The instrument which is shown is located in the pilots' compartment and not necessarily exposed to the elements.

Steel Propeller Blades

The Pratt & Whitney R-2800 engines on both the DC-6 and Convair airplanes are equipped with zinc or gray chromium plated hollow steel propeller blades. The first blades were chromium plated, while later blades are zinc plated. In order to remove ice or prevent the formation of ice on the shank of the blade, an electrically heated Neoprene-coated rubber deicer shoe is installed on the leading edge of the blade. The deicer shoe is attached to the blade by applying a coat of Bostik 1007 primer which is allowed to dry. A coat of Bostik 1008 black cement is then applied and when tacky the deicer boot is installed and the cement allowed to dry. The edges of the deicer boot are then sealed by application of a coat of black Inloid sealer.

In service, the seal occasionally breaks at a point along the edge of the boot and a hole is channelled underneath the boot and comes out at another point. Sometimes, the channel may be as long as two feet. In flight at various altitudes, moisture-laden air is drawn into the channel under the boot and rusting of the blade has occurred on the gray chromium plated blades, as shown in Figure 24. The plating in localized areas and, particularly, on leading edges is also knocked off by flying cinders, stones, sand, etc., on take-offs and landing, when blades are reversed for braking action.

During overhaul of the steel propeller blades at each engine change of about 1000 hours operating time, the rust is removed from abraded and rusted spots and the blades are replated with cadmium about .0003 inches thick. A portable brush plating unit, as shown in Figure 24, is used for the replating operation.

General Corrosion Protection—Exposed Surfaces

It is essential that the manufacturer of the aircraft, at the time of fabrication, make sure that all scuffing

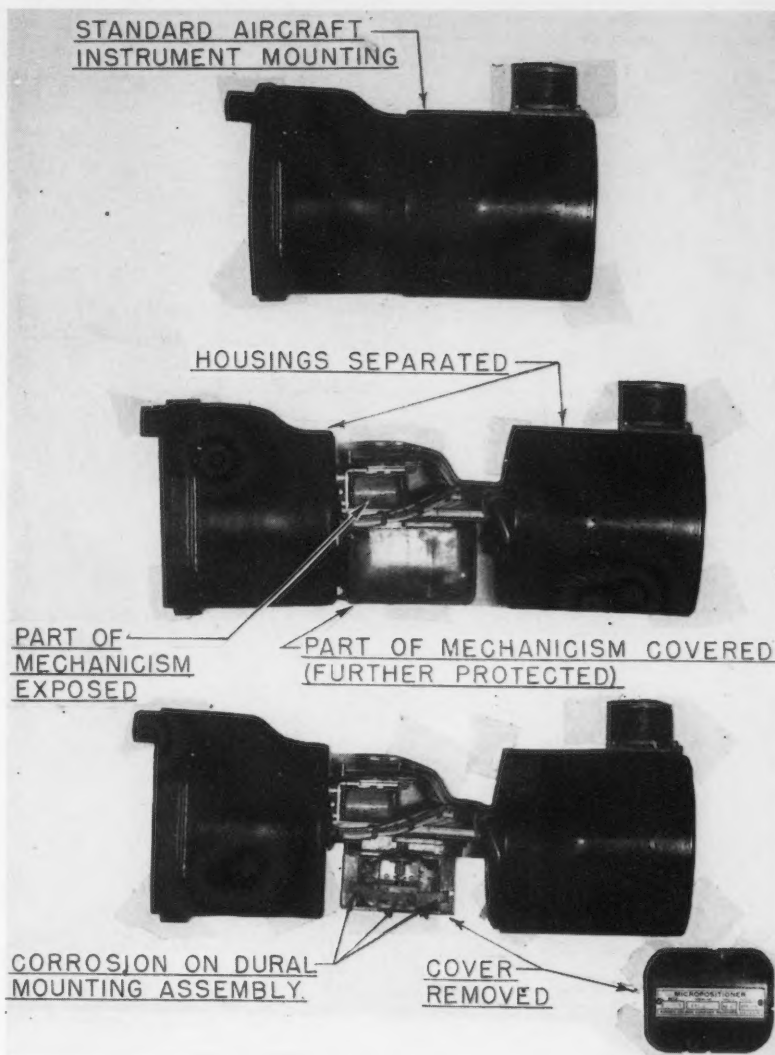


Figure 23—Micropositioner control of Convair cabin pressurization system.

of protective treatment which results from various manufacturing processes such as drilling, riveting, assembly, etc., be retreated before release of the part to the field. The operator finds many instances of such scuffing effect being passed over and, if these parts are in exposed areas, such as fin surfaces, corrosion will start. Most of these items are considered as being of a nuisance character requiring extra time for airline inspections. The effect can be quickly checked with added treatment but adding to the overall time of airplane overhaul. It usually requires one or two rotations of aircraft through the overhaul depot to achieve these modifications.

L-49 Water Tank

The wrapper plate of the L-49 water tank is made of Alclad 24ST and seams riveted with anodized 2SO aluminum and A17ST aluminum alloy rivets. The tank interior is coated with a phenolic coating by filling and draining. Figures 25 and 26 show the interior

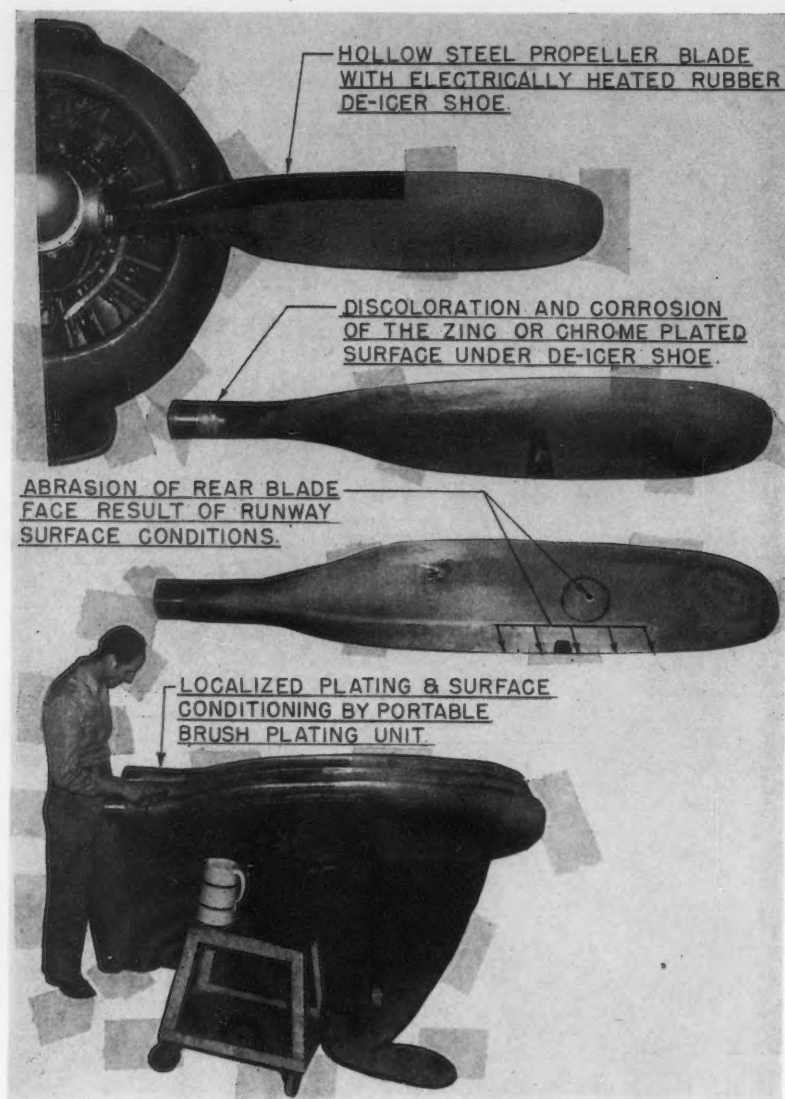


Figure 24

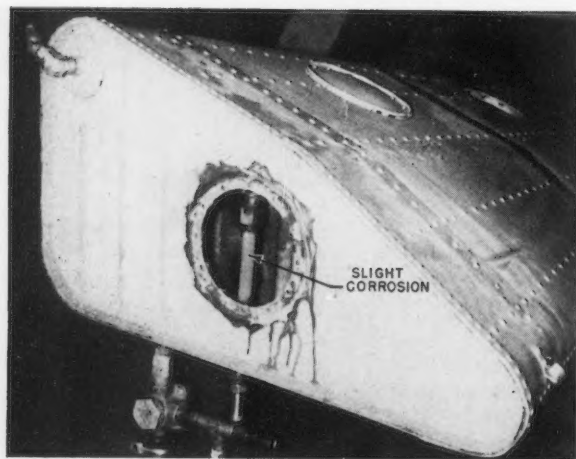


Figure 25—L-49 water tank showing interior phenolic coating and slight corrosion of aluminum tube.

of the tank after being in service about three years. Some 2SO and A17ST rivets have corroded to such an extent that the heads had fallen off. The thin protective phenolic coating on the edges of the rivets has been penetrated and the chlorides and heavy metal content which are present in most drinking water have taken their toll. Undoubtedly, the service life of the tank would have been extended considerably, if the rivet heads on the tank interior had been better protected with a heavy fillet of phenolic coating or other suitable material.

PWA R-2800 Fuel Discharge Nozzle

Water injection is now a commonly accepted method of providing increased power for aircraft take-off needs. By suitable regulators, the metering is accomplished during the take-off periods. This solution of 40 percent water and 60 percent methanol is fed into the fuel lines to the engine. Immediately, galvanic corrosion difficulties began to appear at such points where steel was in contact with magnesium. One of these parts first detected was the fuel discharge nozzle. This unit, which is essentially stainless steel, is inserted into the rear case of the power plant. Surfaces of the steel in contact showed magnesium oxide and the magnesium pad and bore showed considerable etching, as shown in Figure 27. To overcome this tendency on the older engines which were converted to water injection, a phenolic coating was applied to the steel parts to

eliminate the conditions responsible for the corrosion. All new engines are provided with a phenolic sleeve which results in the same protection between the dissimilar metals.

Alcohol-Water Injection System

The Convair airplane is equipped with an alcohol-water injection system in order to increase the horsepower of the engine for take-off. Methyl alcohol is the 99 percent grade, which is purchased in accordance with SAE Aeronautical Material Specification No. 3004. A mixture of 60 percent alcohol and 40 percent water by volume is used for injection. Water for use in the mixture must meet the following purity requirements in order to reduce corrosion of aluminum alloys and magnesium alloys in the engine, lines, and water regulator of the alcohol-water injection system to a minimum:

Total Solids, ppm — 175 max.
Sulfates, ppm — 10 max.

Chlorides, ppm — 15 max.
pH — 6.0 to 8.0

Analyses of water at our various stations, as shown in Table VIII, have revealed that the tap water at only four stations will meet the requirements for water purity. Consequently, it has been necessary to use distilled water, which is purchased locally, or install stills or demineralizing equipment.

There is a soluble oil on the market known as Shell Dromus Oil B, which may be added to the water-alcohol mixture to inhibit corrosion. This material has not been used, since it has been estimated that its use would increase the cost of our alcohol-water mixture by \$30,000 per year. Therefore, steps have been taken to provide good design by the careful selection of corrosion-resistant metals and adequate protective treatments.

Treatment of Corroded Areas

Various methods are used to remove and neutralize the products of corrosion as described below:

Stainless Steel

Exhaust stacks and collector rings are seed blasted with granulated apricot pits to remove heat scale, rust, etc. Lead deposits are removed by immersing in a hot Oakite M-3 solution.

Aluminum Alloy

1. Oil, grease, dirt, etc., are removed with Stoddard's solvent or washed with an emulsion cleaner—kerosene mixture. Carbon deposits are removed with a paint stripper or carbon removal compound. Primer, lacquer and enamels are removed with a paint stripper.
2. Products of corrosion are removed from areas to be painted later with a rotary fine wire brush or by scuff sanding with No. 320 or finer sandpaper.

TABLE VIII—Station Water Analyses

STATION	Total Solids — ppm	pH	Chlorides as NaCl — ppm	Sulfates as Na ₂ SO ₄ — ppm	Remarks	Price of Distilled Water
PWA Requirements	175 Max.	6.0-8.0	15 Max.	10 Max.		
Chicago....	210	7.3	12	26	.....	\$.85/5 gals.
Fort Worth	265	7.7	46	29	.....	.50/5 gals.
Los Angeles	270	7.8	34	35	.....	1.60/5 gals.
Newark....	80	7.8	5	4	O.K.	
New York..	63	6.7	3	1	O.K.	
Boston....	86	6.8	7	20	.....	.14/gal.
Buffalo....	230	8.4	32	36	.....	.75/5 gals.
Cleveland..	215	7.4	41	38	.....	.85/5 gals.
Cincinnati.	261	7.6	31	136	.....
Dallas....	138	9.1	29	40	.....	.50/5 gals.
Detroit....	140	9.9	32	42	.....	1.00/5 gals.
El Paso....	543	8.0	113	150	.....	.10/gal.
Memphis...	39	7.2	8	1	O.K.	
Nashville...	97	7.5	8	36	.....	.15/gal.
Phoenix....	603	7.5	218	164	.....	.75/5 gals.
St. Louis...	217	9.6	24	172	.....	.25/gal.
San Francisco	88	7.6	20	6	Waive	.06/gal.
Tulsa....	84	7.5	9	3	O.K.	.10/gal.
Washington	142	7.7	16	42	.....	.20/gal.

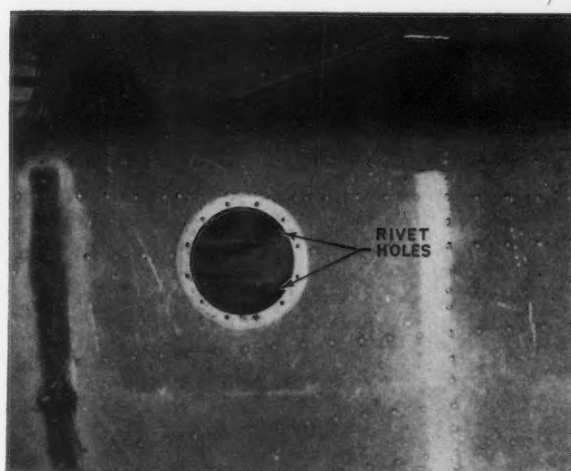


Figure 26—L-49 water tank showing where corroded aluminum rivets have dropped out.

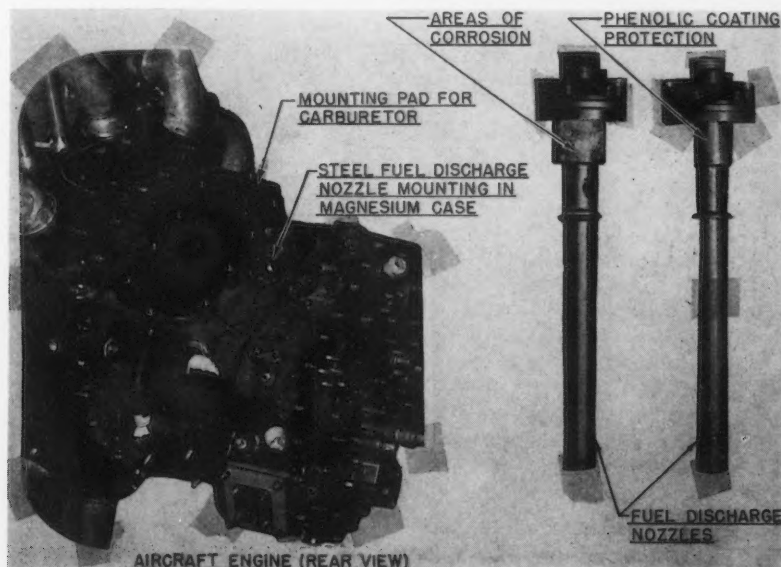


Figure 27

3. Products of corrosion are removed from unpainted polished areas by rubbing with Alumi-Nu No. 9, Type 5060 liquid polish and cloths.
4. When corrosion products have been removed, areas are examined for deep pits and intergranular corrosion (blister-like formations) and, if any are found, the question of serviceability is referred to Engineering.
5. A generous brush or spray coat of a solution of 12 ounces by weight of sodium bichromate per gallon of water is then applied, allowed to dry, and crystals brushed off.
6. Painted areas are then given a cross-spray coat of zinc chromate primer and two coats of lacquer, enamel, or acid-proof paint to match adjacent areas.
7. Battery acid spillages are neutralized by thoroughly flushing with a solution of 4 ounces by weight of baking soda or an alkaline aluminum cleaner per gallon of water, followed by a water rinse. Area is then treated as described in Steps 1 to 6.

Magnesium Alloy

1. Oil, dirt, grease, paint, etc., are removed in a manner similar to that used on aluminum alloy.
2. Products of corrosion are removed with a file or No. 320 sandpaper. The area is then scrubbed with a solution of plater's cleaner, rinsed with water, and dried.
3. Surfaces are then generously brushed with a Dow No. 1 chrome-pickle solution (1½ pounds of sodium bichromate, 1½ pints nitric acid, 3½ pints of water). This solution is allowed to remain on the surface one-half to two minutes, rinsed with water, and dried.
4. A cross-spray coat of primer and two coats of lacquer or enamel to match adjacent areas are then applied.

Steel Propeller Blades

Abraded, scratched or rusted spots on gray chromium or zinc plated steel propeller blades are treated as follows during overhaul:

1. Rust spots, etc. are removed by polishing with fine grade of sandpaper and then cleaned with toluol.
2. Spots are then scrubbed with pumice and a plater's cleaner and rinsed with water.
3. Areas are then brush plated with a cadmium plating solution. About 25 passes are required to obtain the desired thickness.
4. Upon completion of plating, areas are wiped with a water-dampened cloth and dried.
5. The entire blade except the Neoprene rubber decelerator boot is then coated with Quaker Chemical Company's No. TM-2724 clear rust preventive compound.

Preventive Maintenance to Avoid Corrosion

It is up to the airline operator to select cleaning materials, develop cleaning procedures and maintain the protective treatments and paint-type coatings on the aircraft if corrosion is to be kept to a minimum.

Cleaning compounds, polishes, solvents, paint removers, procedures, etc., must have no detrimental effect on the metals, materials and protective treatments or coatings on the aircraft on which they are used or accidentally splashed. It also befalls the lot of the operator to provide better protective coatings to those parts and areas which show undue corrosion in service or, in some instances to replace areas with new metal or material more corrosion resistant. Cleaning materials, etc. are normally selected on the basis of laboratory test data and service tests.

Unpainted and unprotected Alclad 24ST and Alclad 75ST exterior skins on aircraft parked in the open have shown corrosion within several weeks, particularly around areas with exhaust deposits. General corrosion has been noted within three weeks on aircraft stationed near ocean bays. Vinyl-type strippable coatings and certain emulsion-type waxes have been effective in overcoming such corrosion. The main difficulty encountered has been in finding materials which will readily remove such waxes without crazing Plexiglas windows in cabins. The time required to remove these waxes and polish the metal with Alumi-Nu is increased 100 to 200 percent. The vinyl-type coatings are readily removed by peeling off in large sheets.

It is the practice of many airline operators to polish Alclad exterior skin of the aircraft with a polish containing diatomaceous earth such as Alumi-Nu No. 9, Type 5060 Liquid Polish. The polishing operation is done by hand-rubbing with cloths and requires 175 to 200 man-hours for a DC-6 airplane and 65 to 70 man-hours for the Convair airplane. Polishing operations are performed every three to five months.

During the intervals between polishing operations, airplane exteriors are cleaned with an emulsion cleaner-petroleum solvent mixture, when the weather is not too cold. Medium exhaust deposits are removed by mopping with Penetone Company's Navee 427 exhaust stain remover. Heavy carbon deposits are removed with a paint stripper and micarta scraper. The emulsion cleaner is applied with spray nozzles and after allowing to soak for about 10 minutes is rinsed with tap water from a hose. A DC-6 airplane is cleaned by this method in about five man-hours and the Convair in two man-hours.

In winter weather, when wet cleaning is not possible, oil and light exhaust soils on the airplane exterior are removed by mopping with Stoddard's solvent. Dust, soot and other light soils are removed by mopping with Aerogroom cleaner, allowing to dry, and then removing the white powder with clean string mops. This dry cleaning method is usually done in the hangar while other work is being performed on the airplane. Approximately 25 man-hours are required to clean a DC-6 airplane with Aerogroom.

The cleaning of airplane exterior metal surfaces with an emulsion cleaner or Aerogroom cleaner, or the polishing with Alumi-Nu accomplishes two purposes, i.e., 1) a clean, bright appearance results, and 2) soot, dust, dirt, and exhaust deposits which, in the presence of moisture might cause corrosion, are thus removed.

Preservation of Spare Engines for Storage

Spare engines are prepared internally for storage by operating the engine with a mixture of AN-VV-C-576 internal rust preventive compound and aircraft engine oil in the crankcase. While the mixture is still hot, it is drained and the internal walls of cylinder barrels, heads of pistons, rocker boxes, valve ports, etc. are sprayed with Sinclair Rustolene 10 oil using dry air or nitrogen. Dehydrating plugs with silica gel are then inserted in spark plugs and crankcase openings. Bags of dehydrating agent are placed in exhaust stacks and openings sealed with waxed paper. For outside or long time storage, exterior portions of the engine are sprayed with AN-C-52 rust preventive compound and the entire engine then enclosed in a pliofilm heat sealed envelope with bags of dehydrating agent to absorb moisture.

Conclusions

In conclusion, problems of corrosion in air transport aircraft may be reduced to a minimum by observation of the following principles:

1. Good design by the selection of metals possessing good corrosion resistance to liquids and soils encountered in service operations.
2. Elimination of pockets to collect moisture.
3. Avoidance of dissimilar metal contacts or proper insulation by plating or protective paint coatings, etc., where unavoidable.
4. Proper selection, application, and maintenance of protective surface treatments and coatings by good inspection and overhaul procedures.

5. Correct heat treatment of aluminum alloys, especially 17S, 24S, and 75S, so as to develop maximum corrosion resistance.
6. Frequent and good cleaning procedures to remove soils, etc., conducive to corrosion, particularly exhaust gas deposits and liquids splashed around lavatory service valve areas.
7. Proper installation and sealing such as edges of floor coverings around buffet and lavatory areas to preclude spilled or splashed liquids running underneath the coverings.
8. Proper inhibiting and/or treatment of fuels, oils, water, and other materials, when container or other parts cannot be suitably protected with surface treatments.

Acknowledgement

The authors express their appreciation for the help of other American Airlines' personnel in collecting data and assisting in the preparation of this paper.

DISCUSSION

Question by L. W. Smith, Cornell Aeronautical Laboratory, 4455 Genesee St., Buffalo, N.Y.:

In the case of fire aboard and airplane, how does the use of fire extinguisher fluids affect the corrosion resistance of aircraft materials and what steps are taken to prevent corrosion after use of fire extinguisher fluids?

Authors' Reply:

We use inhibited carbon tetrachloride in our fluid-type fire extinguishers. No corrosive effect on aircraft has been observed from the use of such material.

ERRATUM

Five Year Index to Technical Articles. Corrosion, 6, No. 12 (1950) Dec.

Page 11. May - Vol. 5 - No. 5. Topic of the Month—Corrosion in Sour Crude Storage Tanks—By Derk Holstein. 168.

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Topic of the Month

Rail Corrosion in the Moffat Tunnel

By WALTER LEAF*

THE MOFFAT TUNNEL through the Continental Divide is six and a quarter miles long. Ventilation is provided by a forced draft fan driven by a 500 HP motor, which is capable of creating 16 mph air flow. There are numerous wet spots where water drips from the ceiling onto the track, so that the air in the tunnel always has a high humidity. The value of course varies from time to time with variations of humidity and temperature of the outside air.

Operation at present is mostly with Diesel- electric engines, but some steam power operates through the tunnel. Carbon dioxide and water from fuel combustion and evaporation from the steam locomotives create a corrosive condition which attacks rail, tie plates and spikes.

During steam operation, measured loss of metal from the head of the rail was $\frac{3}{8}$ -inch per year in the west end of the tunnel. Ventilation conditions at that time were not as good as now. It is expected that future rail corrosion will not be as great as in the past. However, it will be severe enough to create a problem.

The rail now in the tunnel was laid in the fall of 1950. Previous rail was placed in 1942 and 1943. It was 130 PS section which has a relatively deep head. Two cross sections of this rail, one on top of the other for easy comparison, are shown in the photograph. The top section was taken from a location over a tie plate in the west end of the tunnel where corrosion is most severe. The bottom section was from the east end, between plates, and shows little loss of metal. It will be noticed that considerable metal has been lost from the base of the rail. In fact, it was this condition which made removal necessary. It was felt that several more years life could have been had, if the base had not cor-



Figure 1—Cross-sections of 130 PS section t-rail from Moffat Tunnel are shown here laid one on top of another for comparison of corrosion losses in different parts of the tunnel. The smaller section on top was from rail from the west end of the tunnel at a location over a tie plate; the larger section underneath was from the east end, between plates. Metal lost from the base of the rail near west end was reason for removing it.

roded so much. Since the cost of rail renewal is about \$180,000, yearly cost is nearly \$30,000.

Corrosion of the base, in contact with the plate, is accelerated by collection of moisture at this point and abrasive action from traffic. Several methods of reducing this corrosion are now being tested. The rail is heavily anchored to prevent longitudinal movement, but under traffic there is evidently some slight transverse movement as well as impact. Unit loading ranges up to 250 psi. Consequently it is difficult to retain any protective material or coating between plate and rail. Thin zinc sheet placed between plate and rail is worked out laterally, up the shoulder of the plate. Asphalted fabrics are ground up or extruded. Sheet rubber, specially compounded and $\frac{3}{8}$ -inch thick, will not stay in place unless glued to the plate, or held by a rib over the end. It seems to hold up well mechanically, and may or may not slow corrosion by exclusion of moisture. Chromated felt pads have been installed, but it is feared that they will not hold up under the loading.

Zinc dipped tie plates and spikes have been installed for test. It is thought that this method will give a high degree of protection as long as the zinc lasts, which is an unknown quantity. If protection can be had for four or five years, the base can then be neglected, for head loss will make removal necessary. There are 3300 ties per mile, 6600 plates, or something over 40,000 plates in the tunnel. Probably the east one-third of these need not be protected.

*Research Technician, The Denver & Rio Grande Western Railroad Co., Denver, Col.



NACE News

Sections Outside U. S. Are Being Considered

Coatings Discussion Set at Philadelphia

Two discussions of coating methods will be featured at the May 16 meeting of Philadelphia Section at the Poor Richard Club, 1319 Locust St., Philadelphia. Dinner will be served at 6:30 p.m., followed by business and technical sessions at 7:30.

Vern Smith, manager of sales engineering of Metallizing Engineering Co. will speak on "Corrosion Prevention of Iron and Steel by the Use of the Metallizing Process." George E. Field, technical service manager of plastic materials for B. F. Goodrich Chemical Co. will speak on "Development and Application of Vinyl Resins."

Pittsburgh Section-ECS Meeting Hears Hoar

Dr. T. P. Hoar of Cambridge University, England, addressed a joint meeting of The Electrochemical Society and the Pittsburgh Section NACE April 5 at Mellon Institute, Pittsburgh. J. G. Jewell, of Gulf Research & Development Co. presented an address "Chemical Treatment to Mitigate Corrosion" as the NACE contribution to the technical program. A dinner was held at Webster Hall preceding the meeting.

Scheduled meetings of Pittsburgh Section include:

April 19—Spring Mechanical Engineering Conference, Hotel William Penn, 17th Floor. Co-sponsored by AMHS, ASHVE, ASLE, ASRE, NACE and ESWP. A banquet will be held beginning at 7 p.m. in the Urban Room and a social hour is scheduled from 6 to 7 p.m. in the Fort Duquesne Room. J. Calvin Brown, president of ASME will speak on "Early Patents and Their Influence."

May 3—Joint meeting North East Region and Pittsburgh Section. "Theory of Oxidation," by E. A. Gulbransen, Westinghouse Research Laboratories.

June 7—"Application of Mathematical Statistics to Corrosion Control," by V. V. Kendall, National Tube Co.

Persons wishing to submit answers to questions asked under the column heading "Corrosion Problems" are requested to send duplicate copies of their answers to Central Office, NACE, 919 Milam Building, Houston 2, Texas. Names of persons submitting replies will be omitted on request.

NACE CALENDAR

May

- 8 Houston Section. Effects of Alloying Elements on the Corrodibility of iron, F. L. LaQue, International Nickel Co., Inc.
- 14 Permian Basin Section.
- 15 Cleveland Section. Dinner meeting.
- 15 Chicago Section. Round table discussion.
- 20 Los Angeles Section. Rodger Young Auditorium, Los Angeles.
- 21 Greater St. Louis Section. Effect of Water Treatment on Corrosion in Heat Exchanger Equipment, Leo F. Collins, Detroit Edison Co.
- 22 Cincinnati Section. Panel discussion on pipe corrosion.
- 23 Corpus Christi Section.
- 31 Sabine-Neches Section.

June

- 7 Application of Mathematical Statistics to Corrosion Problems, V. V. Kendall, National Tube Co.
- 11 Permian Basin Section.
- 27 Corpus Christi Section.

S. E. Doughty Talks on Steels at Baton Rouge

S. E. Doughty, metallurgist for Carpenter Steel Company, addressed the March 19 meeting of New Orleans-Baton Rouge Section at Baton Rouge on stainless steel alloys. There were present 22 members and 31 guests.

Next meeting at La Louisiane Restaurant, New Orleans, April 16 is scheduled to hear Paul Bush of Texas Eastern Transmission Corp.

Sections of the National Association of Corrosion Engineers outside the United States are under consideration by the association board of directors as a result of two proposals advanced during the 1951 New York Conference. One, a resolution presented to the board through F. L. LaQue, was received from the Panama Canal Zone signed by three persons employed there in corrosion work. The other was an informal suggestion advanced through A. B. Campbell, executive secretary, that steps be taken to organize a local section in Canada, probably at Edmonton or Calgary. Both proposals were referred to the Policy and Planning Committee for recommendations.

The petition from the Canal Zone, incorporated a suggestion a special form of membership be created by the association whereby four "job memberships" would be equal to one active membership and that one subscription of CORROSION be allowed each group of four such members.

South Central Meeting Scheduled Oct. 18-20

October 18, 19 and 20 have been selected as dates for the 1951 annual meeting of South Central Region at Corpus Christi, Texas. George A. Mills of Central Power and Light Co., Corpus Christi has been named general chairman.

Attendance of about 250 is anticipated.

Derk Holsteyn, Shell Oil Co., Houston, has accepted the post of chairman of the technical program for the meeting.

NACE MEMBERS CHANGING STATUS

Notification to Central Office NACE of changes of membership status, including changes of address should be made *personally* by the member.

NACE is reluctant to make changes in membership records except when asked to do so by members themselves.

Please note also:

1. Active and junior memberships are *non-transferable*, because applications are signed personally by members, therefore
2. All persons wishing to become members of NACE must submit and *sign personally* an application containing a concise statement of qualifications and including the names of two NACE members in good standing as references.

Houston Section Is Host to 40 Students



Over 40 senior and graduate engineering students of University of Houston, A. & M. College of Texas and University of Texas, with their sponsors were guests of Houston Section April 5. R. B. Hoxeng, United States Steel Company Research Laboratory, spoke on "The Role of the Corrosion Engineer in Industry."

Representatives of six companies interviewed over 30 students in connection with corrosion engineering job openings at the Placement Office of University of Houston during the afternoon. Many students learned of the work of the junior corrosion engineer and the employment opportunities in several industries. The evening program was held at Kaphan's Restaurant where 16 local suppliers were hosts at a fellowship hour. Following dinner the group was entertained with movie of the 1951 Cotton Bowl football game.

Mr. Hoxeng's address centered on the economic aspects involved in corrosion mitigation, stressing the necessity for consideration of corrosion factors in plant site selection, layout and design. Proper use of coatings, cathodic protection and inhibitors during the manufacturing process will help save equipment, and the responsibility of the engineer does not cease until the product is delivered to the customer, Mr. Hoxeng pointed out. One principal part of the corrosion engineer's job that must be kept in mind, he added, was public relations work involved in convincing management and customers that corrosion mitigation practices were worthwhile.

F. L. LaQue, head of the Corrosion Engineering Section, International Nickel Co., Inc., will speak at the May 8 meeting on the subject "The Effects of Alloying Elements on the Corrodibility of Iron." The meeting will be at Guy Francis' Restaurant.

Sponsors present were John Roberts, University of Houston Junior Section; John D. Lindsay and H. T. Kennedy, A. & M. College of Texas and Bill Dudley, University of Texas.

Suppliers sponsoring the fellowship hour were Forrest Baskett, Weaver Equipment & Supply Co.; Wayne Broyles, Brance-Krachy Co., Inc.; R. A. J. Dawson, Houston Equipment Co.; E. P. Doremus, Cathodic Protection Service; M. C. Forbes, Aquatrol, Inc.; Jack Harris, Cameron Iron Works; Emil G. Holm, Tube-Kote, Inc.; John E. Loef-

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News about the activities of organizations anywhere in the world engaged in corrosion mitigation are welcomed for use in the news section of CORROSION.

Advance notices of meetings of corrosion interest should be sent to CORROSION in sufficient time to permit publication in an issue distributed before the meetings are held.

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TP-6K Changes Name

The name of Technical Practices Subcommittee 6-K has been changed to "Corrosion Resistant Construction with Masonry and Allied Materials."



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Inhibitors' Value in Non-Drying Coatings Explained by Shoan

Members and guests of St. Louis Section heard Raymond A. Shoan of Dearborn Chemical Company present a discussion of "Inhibited Compounds and Their Importance in Corrosion Prevention" March 19.

Mr. Shoan gave a resume of the mechanism of inhibitors and explained in some detail their use and importance in the non-drying type of protective coating. Among other examples of materials in which inhibitors are important, he said, are paints, cooling waters,

brines, steam return lines, oil wells and pickling and scale removing baths. Vapor phase inhibitors also were discussed.

There is no known universal inhibitor, Mr. Shoan said, and each corrosion problem must be considered carefully for its own peculiarities. More frequently than not, he asserted, combinations of inhibitors are more efficient than single inhibitors.

Mr. Shoan, chief chemist for Dearborn Research Department, has been in Dearborn's employ since graduation from Armour Institute where he received the degree of chemical engineer. His principal work has been with the development of inhibitors and compounds. A member of several technical societies, he has been secretary-treasurer

of North Central Region NACE for the past two years.

Questions raised after his talk indicated the wide interest in the subject and appreciation of Mr. Shoan's paper.

Berry Will Address South East Region

N. E. Berry, Servel, Inc., Evansville, Ind., president of NACE will be after dinner speaker at South East Region's spring meeting May 9. The meeting will be held at Chattanooga, Tenn.

ALONZO V. SMITH

Alonzo V. Smith, corrosion engineer and formerly electrolysis engineer for the United Gas Improvement Co., died suddenly April 2 in Pennsylvania Station, New York on a Philadelphia-bound train. He was 51. He lived at 370 Trevor Lane, Bala Cynwyd and was consulting engineer for many companies operating pipe lines. In 1943 he received the Beal Medal at the 25th annual meeting of the American Gas Association at St. Louis.

A graduate of Rensselaer Polytechnic Institute, he was a member of the National Association of Corrosion Engineers and other professional societies. His survivors include a wife and three children.

ALVIN C. GOETZ

Alvin C. Goetz, 59, manager of the sales and service department of the pigment and oxide division of Eagle-Picher Co. died March 21 at Cincinnati. He became ill five weeks ago in Washington, D. C. while acting as chief of the protective coating section of the National Production Authority.

Associated with Eagle-Picher since 1923, he was a native of New York, and a chemical engineering graduate of Pennsylvania State College. The survivors include a widow, a son, and grandson.

A member of NACE and other technical societies, he was active in arrangements for the 1949 NACE Conference at Cincinnati.

CARL E. HEUSSNER

Carl E. Heussner, 51, with Chrysler Corp., Birmingham, Mich., was buried January 4. A materials engineer, he was credited with solving the nickel shortage during a crisis in the manufacture of the atomic bomb. He was an alumnus of Albion College and Wayne University and held a master's degree from University of Wisconsin and a doctorate from University of Michigan.

His survivors include a widow and three brothers.

An index to the Corrosion Abstracts published during 1950 was published in the December, 1950 issue. The index is a table which gives the month and page number of the topic under which the index is classified.

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Effect of Minor Constituents Is Theme for Gordon Corrosion Conference July 23-27

The 1951 American Association for the Advancement of Science Gordon Corrosion Conference, to be held July 23-27 will have "The Effect of Minor Constituents" as its theme. Restricted to about 100 persons, attendance is by invitation. Those interested in attending may communicate with the conference director, Dr. W. George Parks, Rhode Island State University, Providence, Rhode Island.

Officers of the conference are Frederick W. Fink, Battelle Memorial Institute, Columbus 1, Ohio, chairman and John M. Pearson, Sun Oil Company, Newton Square, Pa., vice-chairman.

The following program has been arranged:

Monday, July 23—Introductory remarks by a speaker to be announced. H. A. Robinson,* Dow Chemical Company, "Magnesium and Other Light Metals."

Milton Stern,† Massachusetts Institute of Technology, "Aluminum Alloys in Carbon Tetrachloride."

M. L. Holsworth,‡ Ohio State University, "Knife-Line Attack in Stabilized Stainless Steels."

Tuesday, July 24—E. M. Mahla,* E. I. du Pont de Nemours & Co., "Stainless Steels."

F. N. Alquist,* Dow Chemical Company, "Minor Constituents in Boiler Water Corrosion."

A. H. Gropp,‡ Assistant Professor of Chemistry, University of Florida, "Polarography in Corrosion."

Wednesday, July 25—C. P. Larrabee,* U. S. Steel Company, "Low Alloy Steels." C. L. Bulow,* Bridgeport Brass Company, "Copper and Copper-Base Alloys."

Thursday, July 26—Thomas P. May,* International Nickel Co., "Selected Non-ferrous Metals."

Walter A. Patrick,* Professor of Chemistry, John Hopkins University, "Gases in Metals."

Friday, July 27—B. W. Dunnington, Ohio State University,‡ "A Metallographic Study of Oxidation."

R. B. Hoxeng,* U. S. Steel Company, "Summary of Discussion of Minor Constituents."

* Discussion chairman for this session. Prepared discussions being solicited from specialists in the field.

† A paper of general interest. In a number of cases the subject matter is closely related to the subject of the conference.

‡ Present address, E. I. DuPont de Nemours & Co., Wilmington, Del.

Hunter Named President Of Electrochemical Society for 1951-52

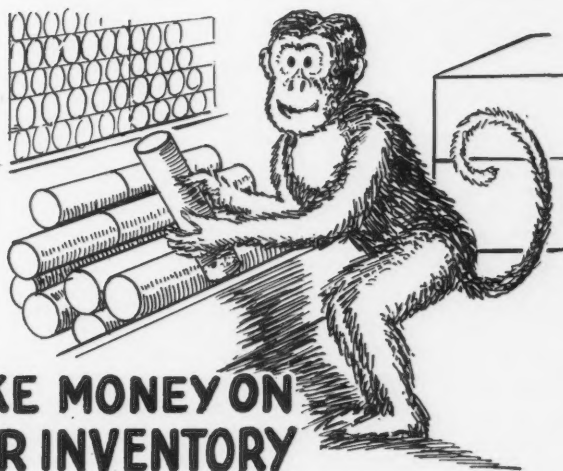
Ralph M. Hunter, manager of the Electrochemical Division of The Dow Chemical Co., Midland, Mich., was named president and Marvin J. Udy, vice-president of The Electrochemical Society in a mail ballot of the society's membership.

Distilleries' Corrosion Is Topic for Meeting Of Cincinnati Section

Speakers from Schenley Distilleries, Jos. A. Seagram's Distillers and National Distillers Products Corp. are scheduled to speak before Southwestern Ohio Section April 24 on corrosion in distilleries at Cincinnati.

Sixteen members and eight guests attended the March 27 meeting at Roselawn Tavern, Cincinnati, to hear several who attended the 1951 NACE Conference in New York give resumes of their experiences. Speakers were Prof. Roy McDuffie of University of Cincinnati, John Davenport of U. S. Corps of Engineers, James Crane of Cincinnati Chemical, Walter Luce of Duriron Corporation, R. B. Stephenson of Dayton Power and Light Co., and William J. Schreiner of Cincinnati Gas & Electric Co.

The constitution and by-laws of the section were presented by Mr. Schreiner and accepted. A nominating committee consisting of John Davenport, R. B. Stephenson, William Schreiner and James Crane was named. Candidates for office were nominated as follows: For president, Joseph A. Creevy (unopposed); for vice-president, Roy McDuffie and Robert Paul; for secretary, William J. Schreiner and Lewis M. Lederer. Four directors are to be named from among the following: V. V. Malcom, Walter A. Luce, William Pfeiffer, L. B. Routson, Robert Rommel and Arthur Castor.



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Seven Symposia Are Scheduled by ASTM

The 1951 Annual Meeting of the American Society of Testing Materials scheduled June 18-22 at Atlantic City, N. J., will be featured by seven technical symposia and an estimated 450 meetings of technical committees.

Several dozen technical papers dealing with ferrous and non-ferrous metals, including high temperature properties and testing, a separate session dealing with lead and its uses and other papers on asphalts, cement and concrete and plastics are scheduled.

Items of Corrosion Interest at Gas Convention Are Listed

Items of corrosion interest scheduled during the Southern Gas Association 43rd Annual Convention at Biloxi, Miss., April 23-25 are as follows:

The design and Construction of Off-Shore Pipelines by R. C. Ledford, The Marine Gathering Company.

Removal of Fluids from Natural Gas Before Entering Pipelines by J. H. Echterhoff, Sohio Petroleum Company.

Best Methods to Obtain and Maintain Maximum Efficiency on Pipelines by

H. M. McDonald, Texas Eastern Transmission Corp.

Use of Mechanized Equipment in the Operation and Maintenance of Pipe Lines by W. C. McGee, Jr., Tennessee Gas Transmission Co.

General Corrosion Practices and Economics by W. A. Broome, Arkansas Louisiana Gas Company.

Corrosion Papers Are Scheduled by ASME

Two papers connected with corrosion are scheduled for presentation April 20 during the two-day American Society of Mechanical Engineers' Pittsburgh Mechanical Engineering Conference at William Penn Hotel. NACE is one of the six participating technical societies.

The papers are entitled:

Scientific Value of Surface Preparation and Paint Application for Use of Designers and Engineers, by A. J. Liebman, Director of Research, Dravo Corp., Pittsburgh, Pa. Mr. Liebman is chairman of NACE Technical Practices Sub-Committee 6G—Surface Preparation for Organic Coatings.

The Production of Electrolytic Tinplate Having Differential Coating Thicknesses, by Samuel S. Johnson, Technical Director, Electrolytic Division, Weirton Steel Co., Weirton, West Va.

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LaQue Will Deliver 1951 Marburg Lecture

F. L. LaQue, in charge of the Corrosion Engineering Section, Development and Research Div., International Nickel Co., Inc., New York City, has been invited by the board of directors of the American Society for Testing Materials to present the 1951 Edgar Marburg lecture at the annual ASTM meeting at Atlantic City, N. J. during the week of June 18.

Mr. LaQue's lecture is scheduled to survey various programs and methods instituted by ASTM, including inadequacies of accelerated testing, distinctions between corrodibility of material and the protective value of its corrosion products and how these are influenced by the composition and incidental conditions of exposure.

Shartle Is Honored By Steel Founders

Thomas H. Shartle, president of Texas Electric Steel Casting Co., Houston, and president of the Steel Founders' Society of America for the past two years was awarded the Lorenz Memorial Gold Medal at the society's annual meeting at Chicago. The society's Technical and Operating Medal for 1950 was awarded to Paul H. Stuff, chief metallurgist, Ross-Meehan Foundries, Chattanooga. G. A. Lilliequist, research director and chief metallurgist, American Steel Foundries, Chicago, received the annual Steel Foundry Facts award for excellence of material published in the society's technical publication.

Lecturers Are Named For Corrosion Course

The subject matter and lecturers for the Massachusetts Institute of Technology one-week course in corrosion June 18-23 have been named as follows:

Fundamentals of Corrosion Reactions and Control, H. H. Uhlig, MIT and Carl Wagner, visiting professor of Metallurgy.

Metals and Alloys: Properties and a Guide to Their Proper Selection, W. Z. Friend, International Nickel Co., Inc.

Cathodic Protection: Theory and

Measurements, J. M. Pearson, Sun Oil Co.; Practice and Economics, L. P. Sudrablin, Electro Rust-Proofing Corp. Metallic and Organic Coatings: Selection, Application and Behavior, R. M. Burns, Bell Telephone Laboratories.

Treatment of Environment, Norman Hackerman, University of Texas.

Design of Equipment from a Corrosion Standpoint, R. B. Mears, United States Steel Corp.

Principles and Practices of Corrosion Testing, F. L. LaQue, International Nickel Co., Inc.

Schedule at The Hague Includes Corrosion

Material of corrosion content scheduled for presentation at the Third World Petroleum Congress, to be held at The Hague, May 28-June 6 has been summarized as follows:

Master Section 8: Construction of Equipment; Materials, Corrosion.

Steel manufacturers stress that considerable progress has been made in the field of refinery piping, especially on the very complex requirements for furnace tubes. This development is not primarily extending the number of steel varieties but

rather extending knowledge of a decreasing number of materials. Problems from the manufacturers' and users' angles are considered. In a contribution on weldability of refinery materials it is made clear oil companies have to maintain considerable research facilities to be able to handle steel materials.

Cathodic protection of submerged pipe lines has become an art. Problems of modern design, calculation and application are brought up for discussion, as well as long-term measurements of effectiveness in conjunction with the economically optimum protective coating. The unsolved problem of asphaltic bitumen versus coal tar is again considered.

Corrosion by petroleum distillates has led to the development of inhibitors of considerable financial benefit. High temperature corrosivity of bunker oil ashes also is considered.

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BOOK REVIEWS

ASTM STANDARDS ON INDUSTRIAL WATER. Prepared by ASTM Committee D-19 on Industrial Water. 160 pages, 6 x 9 inches, paper bound. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Per copy, \$2. This second edition of this publication combines ASTM standards and tentative methods for sampling, analysis and testing of industrial water. The methods were developed for examining water employed industrially for steam generation, or for process or cooling purposes and for examination of water deposits.

It includes 31 methods covering sampling, analysis, corrosivity tests, methods of reporting and general testing; specifications for substitute ocean water and standard definitions of terms relating to industrial water. A list of ASTM symposia and technical papers on industrial water is included.

AMERICAN STANDARD SAFETY CODE FOR VENTILATION AND OPERATION OF OPEN-SURFACE TANKS. 8½ x 11, self cover, paper. 24 pages. Z9.1-1951. American Standards Association, 70 East 45th St., New York 17, N. Y. Per copy 75c. A revision and expansion of the American Standard Safety in Electroplating.

Primary concern of the standard is protection of the operator from effects of operating open surface tanks that might injure his health. Tank operations are divided into twelve classes depending on the relative need for controlling gas, vapor or mist arising from the tank. Tables are included to allow classification of any open tank operation from a knowledge of the tank temperature, boiling point, flash point and relative evaporation rate, and other factors. The appendix at the back includes tables of the resistance to corrosion of materials used for hoods, ducts and exhaust fans, as well as seven pages of typical exhaust hood designs.

Program, Exhibition on Paint Set at Paris

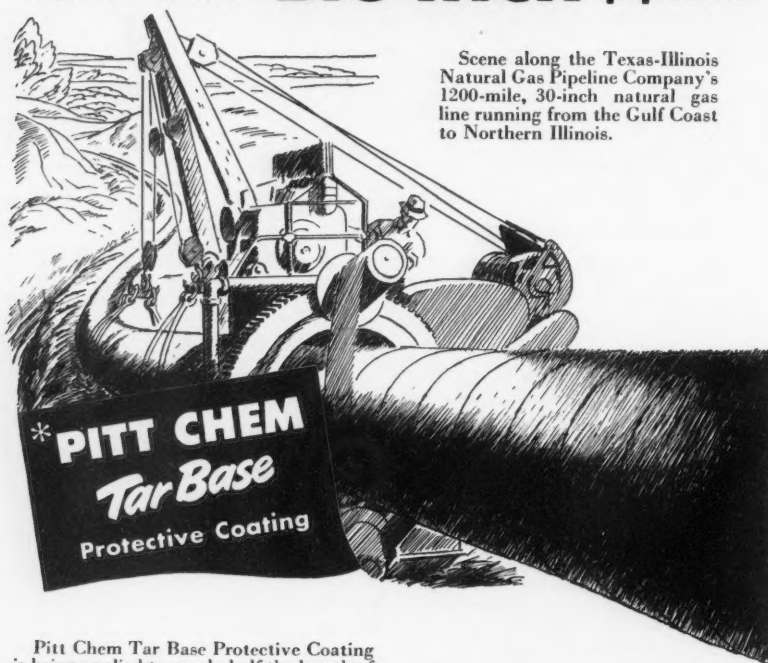
A technical program and exhibition of paint, raw and manufactured materials and equipment for producing paint will be held at Paris, France, May 31-June 6. The program, sponsored by the Federation D'Associations de Techniciens des Industries des Peintures, Vernis, Emaux et Encres D'Imprimerie de L'Europe Continentale, will be held at Maison de la Chimie, 28, Rue Saint-Dominique, Paris (VII), Inv. 10-73.

Four sections have been scheduled for the technical presentations: Definitions and results of laboratory tests, practical experiments—tests; Development of products and their applications, pigments, binding agents; Specialized products, special applications and miscellaneous items, legislation, standardization, hygiene.

The exposition will be held 3-6 June.

Life-Saving "Skin"*

for another **BIG INCH** pipeline



Scene along the Texas-Illinois Natural Gas Pipeline Company's 1200-mile, 30-inch natural gas line running from the Gulf Coast to Northern Illinois.

Pitt Chem Tar Base Protective Coating is being applied to nearly half the length of the new steel pipeline that will soon carry gas from the Corpus Christi area to Joliet, Ill. It's one of the basic materials of a tough, metal-preserving sheath that will guard against underground corrosion and add years of life to the vital line.

This reinforced tar base coating provides more than just "life insurance" for this \$120,000,000 transportation system. Because of its unvarying top quality—maintained by painstaking laboratory control—Pitt Chem pipeline coating performs

better on application, serves better and longer underground.

This same *quality-assurance* is an important advantage when you use any of Industry's Most Comprehensive Family of Protective Coatings . . . whether it's a Pitt Chem Alkyd, Chlorinated Rubber, Vinyl or Phenolic base coating. For more information about these versatile, equipment-saving coatings, send for booklet, "Control Corrosion Through Pitt Chem Protective Coatings."

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Galvanizers Elect

Officers for fiscal 1951-52 were elected as follows by the American Hot Dip Galvanizers Association at its sixteenth annual meeting at Atlanta, Ga., March 21-22: C. L. Moorman, Equipment Steel Products Co., Blue Island, Ill., president; D. B. Noland, of Noland Tank and Galvanizing Co., Nashville, Tenn., first vice-president; Bonnie Trent of Armco Steel Corp., Middletown, Ohio, second vice-president; Stuart J. Swenson, secretary-treasurer and S. J. Swenson, Jr., assistant secretary.

Mauthe Is Selected For McFarland Award

J. L. Mauthe, president of Youngstown Sheet and Tube Co., has been selected to receive the 1951 David Ford McFarland Award for Achievement in Metallurgy. Mr. Mauthe will receive the award May 4 at State College, Pennsylvania, from the Penn State Chapter of the American Society for Metals. The award is given annually to a metallurgy alumnus of Pennsylvania State College.

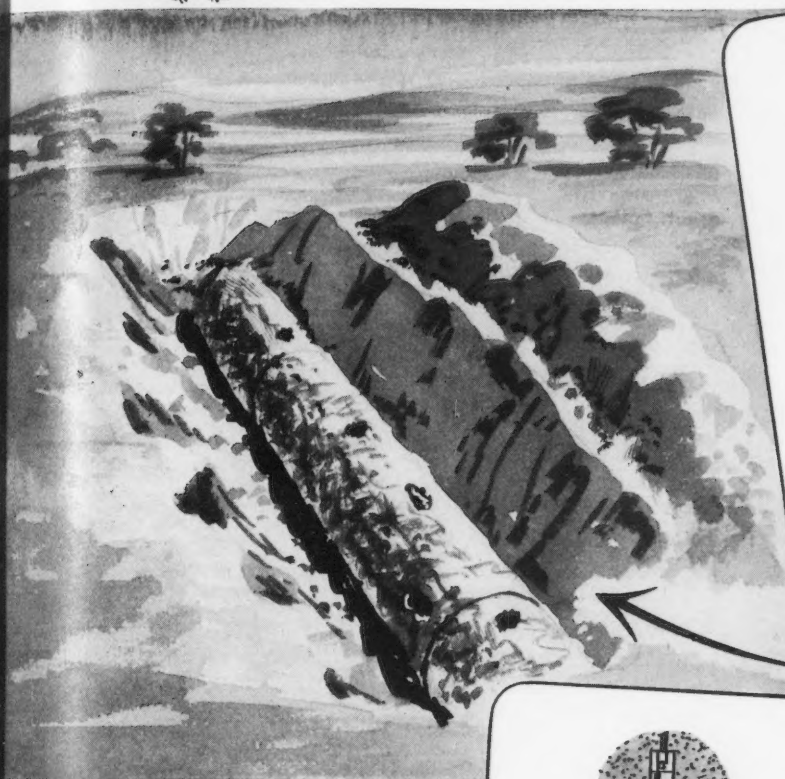
The Editorial Review Committee of NACE will accept papers about corrosion from reliable sources for review to determine if they are acceptable for publication in CORROSION.



Who000000 ...

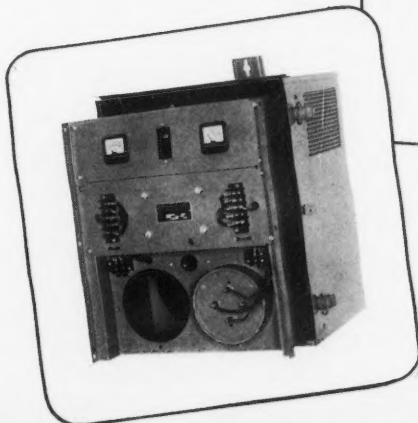
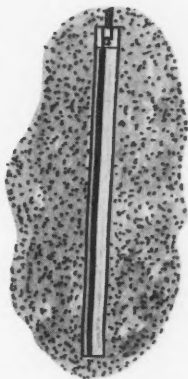
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ground anodes for long life
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Distributors for General Electric and National Carbon Cathodic Protection Products • Offices in Principal Cities

Clippings on Corrosion

Extracted from Current Periodicals

REPAIRS OF DIGESTER TO COST \$9764

(From Des Moines, Iowa *Register*,
Mar. 2, 1951)

A \$9764 contract was awarded for repairs to a sewage digester damaged over the years by corrosion. Steel parts of the tank and large floating roof have been damaged to the point the device no longer is useful.

BERYL IS SOUGHT

(From Dodge City, Kans. *Globe*,
Feb. 17, 1951)

The search for new sources of beryl (beryllium aluminum silicate) found

chiefly in pegmatite, is being intensified. Beryllium, the metal extracted, is used extensively as an alloy because of its fatigue, corrosion and wear resistance.

WEIRTON TINPLATE PROCESS WAR AID

(From Indianapolis, Ind. *Star*, Feb. 11,
1951)

Weirton Steel's new method of coating tinplate with two thicknesses of tin, the one on the outside being sufficient only to prevent rusting of containers from atmospheric attack is believed, one means of reducing the volume of tin used for containers. American Can Company's research toward eliminating tin entirely from containers for most food products has made progress.

SYNTHETIC SAPPHIRE MATERIAL DEVELOPED

(From Kansas City, Mo. *Times*, Feb. 12,
1951)

German scientists working for the air force have developed a synthetic sapphire-like material which retains its properties at extremely high temperatures, remains non-porous and is almost

completely resistant to corrosion under any conditions.

CORROSION REDUCES CITY WATER PRESSURE

(From Wichita Falls, Tex. *Record-Times*,
Feb. 6, 1951)

Corrosion may prevent adequate water pressure in many areas despite installation of hundreds of feet of mains, Maintenance Superintendent Miller Norris said. A two-inch service line was so corroded only a pinpoint of light showed through the pipe. Lake Wichita and Lake Kemp water built the deposits over 25 years. The corroded cast iron pipe is being replaced with concrete asbestos.

NEW LUKENS CLADMETALS AID IN DEFENSE

(From New York *Times*, Mar. 15, 1951)

Lukens Steel Company's development of copper and aluminum-clad steel plate has been called a fruitful avenue for saving in the defense effort by substituting the clad materials for solid structures of copper and aluminum. As much as 92 percent of the critical metal is saved in some instances.

Improved Methods Reduce NACE Reprint Costs

Discovery of a new method for preparing direct printing plates for making reprints, together with numerous other economies reflecting more efficient operation have brought the unit cost of reprints sold in 1950 by National Association of Corrosion Engineers down to about 50 percent of the 1949 cost per unit, information compiled by C. E. Thorney of Central Office staff indicates. The unit cost of reprints printed in 1950 was .058 per copy, whereas the unit charge for 1949 was .108 per copy.

Savings effected by economies in operation are passed on to reprint purchasers immediately by the association because sale prices are based on cost plus an authorized additional charge.

Costs Are Comparable

The association's charges for reprints have been criticized in the past as being too high. While the policy of the association respecting reprints has not changed, (that is, reprints are not made of technical material as a matter of course and offered for sale in single copies), the charge for quantity orders has been reduced materially. "We feel this reduction in our costs will be advantageous to our members and others in corrosion work," A. B. Campbell, executive secretary of the association said. "Our Type 2 Reprint is economical

and makes possible purchases of small quantities at a reasonable price," he said.

The association will make to order reprints of technical material published in *CORROSION*. Orders and inquiries should

be addressed to Norman E. Hamner, Managing Editor, *Corrosion*, 919 Milam Bldg., Houston 2, Texas.

The following schedule of Tentative Prices for Reprints is subject to change without notice:

REPRINTS—TYPE 2

1) Printed in black ink on 8½" x 11" Bond paper. 2) Single sheets stapled once in the upper left hand corner. 3) Running heads and folios NOT changed. 4) No credit line.

Pages	50	100	200	250	300	400	500
1.....	\$ 5.30	\$ 5.63	\$ 6.39	\$ 6.81	\$ 8.67	\$ 9.36	\$10.14
2.....	10.38	10.88	12.07	12.73	14.80	15.85	17.07
3.....	15.18	16.01	18.34	19.42	22.22	24.26	26.56
4.....	19.44	20.43	23.20	24.52	27.53	29.93	32.66
5.....	24.09	25.41	28.87	30.81	34.45	37.74	41.35
6.....	28.35	29.83	33.73	35.91	39.76	43.41	47.45
7.....	33.00	34.81	39.67	42.14	46.69	51.86	56.12
8.....	37.26	39.23	44.53	47.24	52.00	57.53	62.22
9.....	42.56	44.86	50.92	54.05	60.67	66.89	72.36
10.....	47.64	50.11	56.60	59.97	66.80	73.38	79.29
11.....	52.44	55.24	62.87	66.66	74.22	81.79	88.78
12.....	56.70	59.66	67.73	71.76	79.53	87.46	94.88

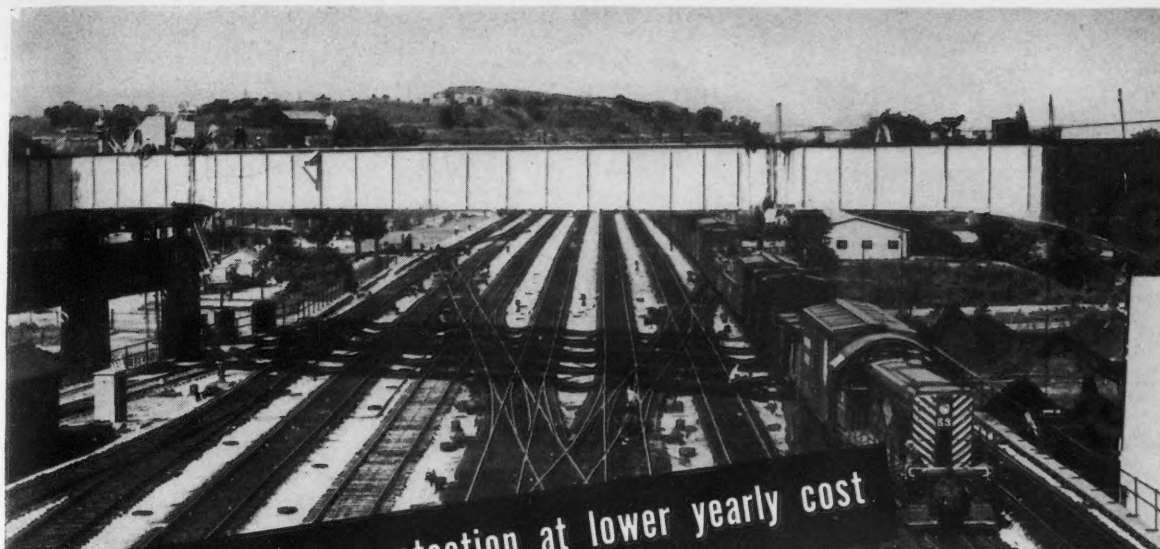
NOTES: 1) For an additional title page, add, for any quantity, \$7.50. 2) For quantity over 500 ask for special quotation. 3) For reprints in excess of 12 pages ask for special quotation.

REPRINTS—TYPE 1

1) Printed in black ink on 70 lb. 8½" x 11¼" white enamel stock. 2) Folded, saddle stitched with two wire staples, trimmed flush. 3) Running heads and folios changed. 4) Credit line added to first page, or, where separate title page is used, to title page.

Pages	100	200	250	300	400	500	600	700	750	800	900	1000	Add'l. 500	Add'l. 1000
1.....	\$ 13.26	\$ 14.41	\$ 14.98	\$ 15.55	\$ 16.71	\$ 17.85	\$ 19.00	\$ 20.15	\$ 20.71	\$ 21.30	\$ 22.47	\$ 23.59	\$ 5.74	\$11.47
2.....	19.77	21.67	22.63	23.59	25.50	27.42	29.32	31.24	32.19	33.15	35.07	36.97	9.57	19.12
4.....	43.09	45.39	46.54	47.68	49.98	52.17	54.57	56.86	58.02	59.16	61.45	63.75	11.47	22.95
8.....	80.58	84.66	86.70	88.74	92.82	96.90	100.98	105.60	107.10	109.14	113.22	117.30	20.40	40.80
12.....	123.67	130.05	133.24	136.42	142.80	149.07	155.55	162.46	165.12	168.30	174.67	181.05	31.87	63.75

NOTE: 1) For an additional title page, where unused pages are available, add, for any quantity, \$7.50. 2) For quantities over 2000 ask for a special quotation. 3) For reprints in excess of 12 Pages, ask for a special quotation. 4) For specifications different from standard herein, ask for special quotation.



positive corrosion protection at lower yearly cost

Kansas City—girders of highway overpass metallized with .012" zinc to protect the steel from corrosive effects of locomotive flue gases.

with pure metallized zinc and aluminum

The long-lasting, corrosion resistant qualities of pure metallized zinc and aluminum coatings are well known. Life expectancies for protective coatings of this nature, properly applied, range upwards of 20-30 years without further attention.

The Metco Systems, a new series of 18 basic engineering specifications developed by Metallizing Engineering Co., cover the protection of structures and equipment under a wide range of corrosion conditions, including immersion in salt or fresh water of various pH values; exposure to water ballast, condensate and some mild acid solutions, and to salt, humid, rural and industrial atmos-

pheres ranging from light to heavy.

The Metco Systems are the result of over 19 years' experience with pure zinc and aluminum coatings on many different types of structures and equipment. They provide the answer to standardization of surface preparation, coating thickness for various service conditions and after-coatings to meet specific requirements.

The Systems also provide for meeting appearance requirements with specific organic coatings in a range of colors, all thoroughly tested for compatibility with the metallized zinc and aluminum.

*Reg. U. S. Pat. Off.—Property of Metallizing Engineering Co., Inc.

Metco System contractors

The following organizations are set up to provide positive corrosion protection at lower annual cost in accordance with Metco* System specifications. For further information, or a copy of descriptive bulletin, contact the one nearest you.

Brooklyn, N. Y.
**ARTHUR TICKLE ENGINEERING
WORKS, INC.**
21 Delevan Street
Tel: Main 5-4200

New Orleans 13, Louisiana
GULF ENGINEERING CO., INC.
1000 South Peters Street
Tel. Canal 4421

Newport Beach, California
CLARK METALLIZING, INC.
506—30th Street
Tel. Harbor 2509

Barberton, Ohio
AKRON SAND BLAST CO.
50 E. Springfield Rd.
Tel. Plaza 3412

Buffalo 1, N. Y.
METAL-CLADDING, INC.
Lakeview & Porter Avenues
Tel. Elmwood 9536

Lincoln Pk. 25 (Detroit), Mich.
DIX ENGINEERING CO., INC.
1417 Dix Road
Tel. Dunkirk 1-8822

Philadelphia 29, Pa.
METALWELD, INC.
Fox & Hunting Park Ave.
Tel. Radcliff 5-3471

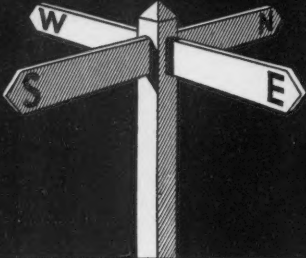
St. Louis, Missouri
NOOTER CORPORATION
1420 South Second Street
Tel. Main 6000

New London, Conn.
**THERMAFLO METAL
PRODUCTS, INC.**
50 Dell Avenue
Tel. 2-4300

Houston, Texas
F. W. GARTNER CO.
3805 Lamar Avenue
Tel. Atwood 5338

Persons wishing to submit answers to questions asked under the column heading "Corrosion Problems" are requested to send duplicate copies of their answers to Central Office, NACE, 919 Milam Building, Houston 2, Texas. Names of persons submitting replies will be omitted on request.

"serving all pipelines"



**PIPELINE COATINGS
and
WRAPPING MATERIALS**

S. D. DAY COMPANY

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Corrosion Problems

E. A. TICE, Editor

Corrosion Engineering Section, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Submit questions and answers for this column in duplicate to the editor. All questions become property of NACE. Questions and Answers may or may not be published under this heading, and may at discretion, be answered by mail directly. Answers to questions are solicited. Authors of questions will remain anonymous to readers while authors of answers may remain anonymous if they request it.

NEW QUESTIONS

No. 83—For several years we have produced ammonia absorption refrigerators and have experienced some corrosion on the inside of the boiler where the ammonia is heated.

The steel tubes employed (0.15% Cu max.) are cleaned with trichlorethylene, and before the unit is charged with refrigerant no foreign matter is present in the unit. 0.2% sodium dichromate is added to the refrigerant as an inhibitor, which is common practice with this type of refrigeration.

From a lot of 100 units all produced at the same time and in the same way, we may have 10 units which corrode from the inside after some years, while the other 90 appear to be unaffected. The reason for such corrosion is not clear to us and we should like an explanation of the cause of this sporadic attack. The only reference which we have found is the U. S. Bureau of Standards Technological Paper No. 180, 1920 "Causes and Pre-

vention of Non Condensable Gases in Ammonia Absorption Refrigerating Machines."

No. 84—In view of the current demands for critical corrosion resistant materials the use of electroplated coatings to replace solid alloy equipment for chemical processing and shipping units could greatly conserve metal. Has the art of nickel plating progressed to the point where nickel coatings, deposited either electrically or chemically, can be used as a substitute for solid nickel in services such as hot caustic soda solutions?

No. 85—How extensively can industry use paint preheating equipment without harmfully affecting the pigment's or the vehicle's protective value? Does preheating of paint allow safe paint application at lower atmospheric temperatures than is present practice?

No. 86—Mixtures of concentrated nitric and hydrofluoric acids at room temperature are used for bright etching silicon-bearing aluminum alloys, or to prepare them for anodizing. Graphite or wax-lined lead containers have been used in the past, but neither is very satisfactory. What materials might give reasonably good service? Is polyethylene or tetrafluoroethylene appropriate, either as a molded container or in coating form? The acid mixtures range from 1 part 48% HF and 8 parts 70% HNO₃, to 1 part 48% HF and 3 parts 70% HNO₃.

Electroplaters Society

"Some Engineering Aspects of Plating Room Operation," by William Blum of the National Bureau of Standards will be the keynote address for the American Electroplaters' Society annual convention at Buffalo, N. Y. July 30-August 2, 1951.

AWWA Officers Named

Officers of the American Water Works Association have been elected as follows: Dr. A. E. Berry, president; Chas. H. Capen, vice-president, and Wm. W. Brush, treasurer.

Steel Castings Booklet

The Steel Founders' Society of America, 920 Midland Bldg., Cleveland 19, Ohio again has available for distribution copies of the 34 page booklet giving case histories of uses to which castings may be put. Copies may be secured on request.

MEMBERSHIP CARDS AVAILABLE

Association members in good standing will be issued on request a membership card in the National Association of Corrosion Engineers. Address requests to A. B. Campbell, Executive Secretary, 919 Milam Building, Houston 2, Texas.

"PAT" HAND AGAINST CORROSION

Corrosion losses affecting buried and submerged structures can be stopped quickly and effectively when you play the cards provided by Electro Rust-Proofing cathodic protection service.

For pipe lines, tank bottoms, buried cables, water tanks, off-shore drilling platforms, condensers, etc., ERP engineering services are available on a contract or per diem basis as required by each individual job. These services include surveys, design and engineering all conducted by capable field engineers utilizing precision testing instruments.

Where the engineering work indicates that cathodic protection is necessary, the ERP Contract Department is ready to take over the furnishing of equipment and materials, installation and maintenance on practically any basis suited to the needs of the job.

Write today, without obligation, for additional information and technical publications.

REPRESENTATIVES IN PRINCIPAL CITIES

Electro Rust-Proofing Corp. (N. J.)

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E-18

CATHODIC PROTECTION FOR ALL BURIED AND SUBMERGED STRUCTURES

Watch your pipeline

GO IN FAST

when you wrap with high-strength **Vitron** UNDERGROUND PIPE WRAP

More Pipe Wrapped Per Day—new records are being set with high-strength VITRON Underground Pipe Wrap. It's a fact—you can roll all day without a break in the wrap because it's **parallel-reinforced** with strong glass yarn.

Less Downtime—VITRON-wrapped jobs can go ahead without a stop, roll after roll. That's because it's strong — individual filaments are bonded together securely. It pulls in fast and taut.

Lays in Smooth—because it's porous, allows coating to bleed through evenly for a uniform, all-around-the-pipe protective covering.

Better Finished Job—every mile of pipe wrapped with VITRON promises uniform corrosion-combating properties—with greater impact and stress resistance, fewer "holidays" and greater moisture resistance to help maintain a high dielectric rating.

Write for samples and descriptive engineering material.

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UNDERGROUND PIPE WRAP

**VITRON WRAP
WORKS
UNDERGROUND**

resists impact and stresses, cold flow
and cracking of coating
resists moisture penetration
resists soil acids
helps maintain high dielectric rating

Distributors & Contract Applicators of:

AMERCOAT maintenance coatings and tank linings.

OSPPO, phosphoric-dichromate surface preparation.

CARLON plastic pipe.

OXYCHLORIDE, mineral cement tank floors and linings.

WE OFFER the following services in Texas and Louisiana:

I A GUARANTEED maintenance program on tanks and steel structures wherein a pre-determined cost extending over 9 or 12 years, averaging 4 cents per year, per square foot can be properly budgeted.

II TANK LINING service with fully proven protective linings for **Sour Crude, Acid Sludge, Run Down, Acid Storage, Caustic Storage and Floating Roof Tanks.**

III EFFECTIVE, and fully proven service on **LINING Tubular Goods, Treaters and Wash Tanks, Salt Water Disposal Pipe, Drill Tubing.**

CORROSION ENGINEERING CO.

Allen D. Stafford, Pres.

1814 Richmond Houston 6, Texas
Phones JA-7222—KE-5136

FREE ADVERTISING FOR NACE MEMBERS

Decisions reached at the August 5 meeting of the National Association of Corrosion Engineers' executive committee have made available free advertising in Corrosion magazine under the headings: Positions Wanted and Positions Available.

Active members may use two consecutive insertions yearly consisting of not more than 35 words set in the standard text type.

Corporate members may use an unlimited number of advertisements consisting of not more than 35 words set in standard text type.

Firms not members but eligible to become corporate members also may use an unlimited number of advertisements consisting of not more than 35 words set in the standard text type.

Individual persons, not members, are not entitled to free advertising on any basis.

Advertisements of any nature or size or frequency which are different from or in excess of 35 words set in standard text type will be charged for at an appropriate rate, the minimum charge being \$5.00.

Sixteen Inter-Society Corrosion Committee Members Report on Activities During 1950

The Inter-Society Corrosion Committee consists of delegates appointed voluntarily by the technical societies and government agencies of North America working in the field of corrosion. The objectives and scope of the committee are to promote cooperation, act in an advisory capacity, recommend new activities, stimulate publication of data, provide information on coming meetings and promote standardization of definitions and terminology in the field of corrosion. Facilities for the functioning of the committee are provided by the National Association of Corrosion Engineers.

The committee meets at least once each year. Approximately 30 organizations have appointed delegate members. Each year the committee asks each member organization to report on its current activities in the corrosion field. Sixteen such reports covering work during the past year have been received to date. Others are expected.

Activities reported were as follows:

Federation of Paint and Varnish Production Clubs

Corrosion work being conducted by the Technical Committee of the New England Production Club. During 1950 the committee continued evaluations of panels exposed in its original investigation of "Primers for Ferrous Metals in Atmospheric Exposure." In September, 1950, all panels and angle irons were re-photographed. A technical paper on the tests will be given at the Federation convention in November, 1951.

The original investigation has been extended to include a project entitled "Surface Preparation of Structural Steel and Its Effect on Life of Subsequently Applied Primer." Seven methods of surface treatment will be used: Sandblasting, pickling, wire-brushing, flame-cleaning, phosphoric acid wash, linseed oil-solvent wash and vinyl type primer. Substrata will be hot rolled steel plates 6 x 12 x 1/4 inch, some of which will be preweathered at Ashland, Mass., and Everett, Mass., the latter representative of very severe industrial exposure. About 200 panels will be used.

Office of Naval Research

The following is a current list of investigators and universities participating in the ONR Fundamental Research Program:

H. H. Uhlig, Massachusetts Institute of Technology. Studies on the nature of passivity and its relationship to electronic configuration.

M. G. Fontana, Ohio State University. Passivity studies, oxidation studies, studies on mechanism of corrosion reactions.

M. T. Simnad and others, Carnegie Institute of Technology. Oxidation studies, passivity studies on stainless steels, effect of stress on metal-ion exchange in solution.

Norman Hackerman, University of Texas. Effect of hydrogen on corrosion of iron and steel.

W. A. Patrick, Johns Hopkins University. Effect of hydrogen on corrosion of iron and steel.

Paul Delahay, Louisiana State University. Oscillograph polarography.

H. J. Yearian, Purdue University. Oxidation studies on iron-chromium alloys.

D. D. Cubicciotti, Illinois Institute of

Technology. Studies of metal-salt reactions at high temperatures.

G. Hill, University of Utah. Studies on the corrosion of metals in contact with liquids.

Related ONR programs:

Carl Zapffe, C. A. Zapffe Laboratories. Study of cases in metals with emphasis on role of hydrogen in embrittlement of steels. Plating and pickling processes and effects of heat treating atmospheres are being evaluated.

E. R. Parker, University of California. Studies of environment on creep of metals.

T. A. Read, Stanford University. Influence of Liquid media on creep of metals.

O. C. Shepard, Stanford University. Effect of environment on high temperature strength of metals.

National Research Council (Canada)

Associate Committee on Corrosion Research and Prevention

Laboratory corrosion testing—A program to determine reproducibility of the following tests: Salt Spray Cabinet (ASTM B 117-49T), painted steel electroplated steel, 24ST aluminum. Humidity cabinet (AN-H-31), painted steel, electroplated steel. Weather-O-Meter (Atlas Single Arc Type), painted steel. The painted steels receive one coat of marine priming paint. Similar panels will be exposed to industrial and marine atmospheres. Others will be given laboratory resistance capacitance, potential survey while similar measurements will be made during sea water immersion (in situ).

Recommendations on corrosion test clauses were made for Royal Canadian Navy paint specifications.

Outdoor Corrosion Testing—The division of Building Research has completed arrangements for four atmospheric corrosion test sites in addition to that at Ottawa: Halifax, N. S., industrial-marine and pure marine; Montreal, Que., industrial and Saskatoon, Sask., dry-rural. An area at Baker Lake, about 150 miles northwest of Churchill, Man., is expected to become available in 1951 as a test site for far northern climate. Stands and frames patterned after U. S. practice, but adjustable to 30 or 45 degrees will be used. The subcommittee is in communication with ASTM.

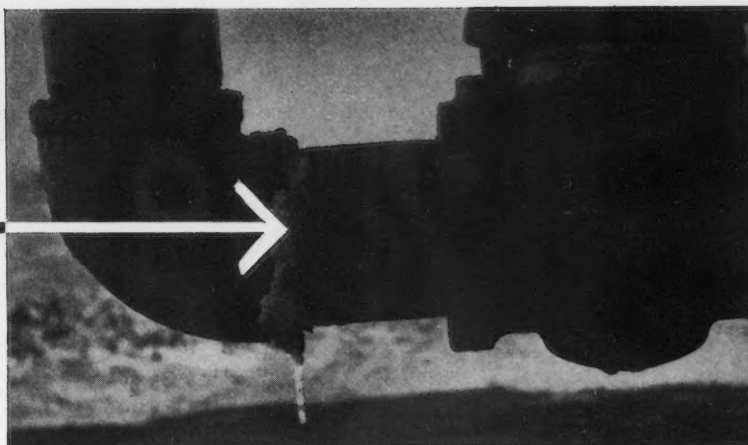
Fundamental Corrosion Research—Four research grants from government funds were made available to university students through the subcommittee on the following projects: Aluminum oxide barrier layers, unidirectional stress corrosion, study of single crystals, potential-pH diagrams and polarization studies on magnesium.

A symposium on electrochemistry and corrosion was sponsored jointly with the Physical Chemistry Section of the Chemical Institute of Canada at Ottawa November 23-24.

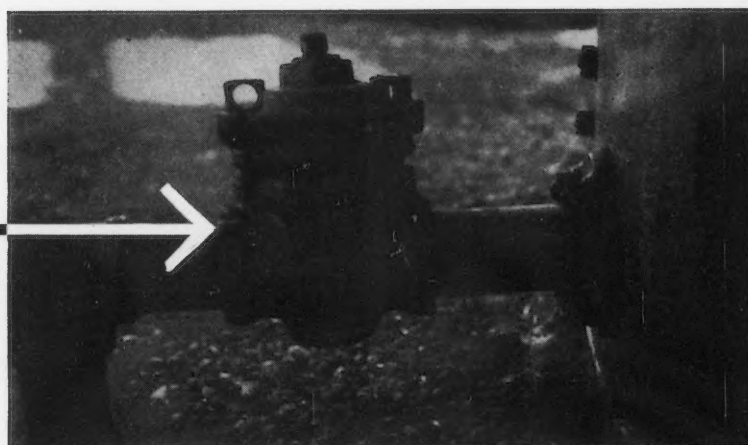
Subcommittee members, who are mostly university staff members, are carrying out research on the following topics: inhibition of corrosion, marine protective coatings, marine cathodic protection, gray tin formation, unidirectional stress corrosion, aluminum oxide

(Continued on Page 16)

**STOP
THIS**



**GET
THIS**



WITH COATINGS BASED ON VINYLITE BRAND RESINS!

These two plug valves and connections in Texas oil field flow lines are proof of the effectiveness of the protective coatings based on VINYLITE Brand Resins!

Both assemblies were installed to carry salt water and basic sediment from storage tanks. The uncoated metal sprang leaks in two months. The coated metal shows no appreciable corrosion after more than two years!

On oil well equipment asea and ashore, as in refineries, chemical plants, acid plants, sewage disposal plants, breweries—coatings based on VINYLITE Resins are par-

ing maintenance costs, reducing shut-downs, and protecting equipment, for more and more operators. These coatings are easily applied. Durable and impact resistant, they strongly resist water, weather, and sunlight, in addition to oils, greases, alkalis, and most strong acids and other chemicals.

On metal or concrete, they keep containers from damaging contents, and contents from injuring containers. They are odorless and tasteless. Available in a wide range of colors, they have excellent integrity and bond.

For more information on coat-

ings based on VINYLITE Brand Resins, and a list of representative suppliers, write Dept. KF- 69J.

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Sixteen Inter-Society—

(Continued from Page 14)

barrier layers, single crystal properties and electrode mechanism.

American Electroplaters Society Research Committee

The following numbered projects were in progress:

4. Effect of surface finishing of non-ferrous base metals on the protective value of plated coatings. Attempts to prepare reproducible flat panels of zinc base die castings were abandoned. Three series of chromium and nickel plated brass panels exposed outdoors will be evaluated in a report when tests are completed.

5. Effect of impurities in plating solu-

tions. Results on the effects of copper in nickel plating solutions on protective value of coatings was published, showing as little as 10 ppm copper can cause 20 percent loss of salt fog resistance, and a 60 percent loss with nickel plated from a solution containing 50 ppm copper. Experiments on effect of zinc impurity in nickel baths are complete and paper being prepared to show zinc tends to improve salt fog resistance of nickel electrodeposits. Current work is on the effect of iron impurity in nickel baths.

6. Nature of porosity of electrodeposits and its effects. Work in the past year has made clearer relations between gas permeability of electrodeposits and their resistance to corrosion. Paper VI from the series on this project shows surface structure of basic metal, as influenced by pol-

ishing, etching or coating can affect permeability and corrodibility. Paper VII demonstrates usefulness of gas permeability measurements. Paper VIII proves nickel coatings showing permeability to gases nevertheless are not permeable to liquids and protect until perforated by corrosion of nickel layer. Paper IX demonstrates relation between protective value and permeability of several varieties of nickel deposits.

Current efforts are towards establishing the mechanism of corrosion toward certain electrodeposits by successive analyses of corrosion products to determine the change of ratio of basis metal and coating metal ions in the products as corrosion progresses.

13. Relationship between permeability and protective value of electroplated coatings. This new project initiated at National Bureau of Standards in September, 1950, is designed to find a new means of determining protective value of the coatings superior to the salt fog test.

Advisory Committee on Accelerated Tests for Electrodeposited Coatings. A committee was organized under F. L. LaQue to make recommendations to the research committee regarding the advisability of undertaking research on improving accelerated tests. It was recommended some modification of the salt fog test be sought which will give results comparable to corrosion in industrial city atmospheres.

National Association of Corrosion Engineers

Meetings were held by NACE as follows: National Conference, St. Louis, Mo., in April; South East Region, April; North East Region, New York City, May; Rochester, November; South Central Region, Houston, October; South East Region, Birmingham, November.

Short courses were sponsored as follows: By Tulsa Section, February; Shreveport Section, September; Case Institute, September. NACE is cooperating in short courses at Stevens Institute.

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American Society for Test Materials

Following is a summary of the corrosion work under way by ASTM. Further details are given in committee reports for 1950.

Advisory Committee on Corrosion—Facilities have been installed at four test sites: New York City, State College, Pa.; Columbus, Ohio and the Canal Zone. Arrangements have been made for establishing test sites at: Kure Beach, N. Car.; Point Reyes, Cal.; Port Aransas, Texas. The committee also has drawn up regulations for use of test sites by other than ASTM committees.

The committee also is working on a bank of test specimens, and is planning a stress-corrosion cracking research program.

Committee A-5 on Corrosion of Iron and Steel—Specimens of bare steel, zinc-coated, copper-covered, chromium and chromium-nickel steel wires and wire products have been exposed for 13 years at 11 locations, including severely industrial, rural and seacoast atmospheres. Extent of corrosion is measured by visual

(Continued on Page 18)

CORROSION

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Sixteen Inter-Society—

(Continued from Page 14)

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the Rocky Mountains

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Sixteen Inter-Society—

(Continued from Page 16)

examinations and tension tests on unfabricated wire specimens.

Hardware specimens are exposed at Sandy Hook, N. J. and State College, Pa., more than 20 years. Corrugated galvanized sheets have been exposed 24 years and copper and non-copper bearing sheets exposed at Annapolis since 1916.

Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys—A publication "Data on Corrosion and Heat-Resistant Steels and Alloys—Wrought and Cast, STP No. 52-A" is a compilation of data on wrought hardenable and non-hardenable ferritic straight chromium steels, and wrought austenitic chromium-nickel steels and the cast alloys of these general composition ranges.

A special sub-group is surveying methods for cleaning vessels to eliminate surface contamination or foreign metal, scale contamination, etc., after fabrication.

Subcommittee IV of this committee is cooperating with the High Alloys Committee of the Welding Research Council and is arranging for preparation and subsequent long-time plant corrosion tests of a large number of welded specimens in several compositions of stainless steel given various heat treatments.

Plans for an extensive atmospheric exposure testing program of stainless steels have been completed and the committee now is proceeding with collection of samples.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys—Study of comparative atmospheric corrosion of iron and zinc specimens at different test

sites continues. The sub-committee on galvanic and electrolytic corrosion has completed exposure of Part I of its three-part magnesium program, which consisted of coupling disk-type specimens. Part II consists of spool-type specimens and Part III plate type specimens. O. B. Ellis, a member of this committee won the 1950 Sam Tour Award for his paper "Effect of Weather on the Initial Corrosion Rate of Sheet Zinc."

The subcommittee on weather is planning to survey instruments and methods for measuring atmospheric pollution resulting in corrosion.

Committee B-4 on Electrical Heating, Resistance and Related Alloys—A review of 11 years of tests on a single wire lot pointing up the difference in seasonal results on life test values believed largely the result of humidity has been made.

The work program on deterioration, "green rot" effects and behavior of alloys in atmospheres containing sulfur and moisture is continuing.

Committee B-6 on Die-Cast Metals and Alloys—Subcommittee V on Exposure and Corrosion Tests has completed testing zinc and magnesium base alloy test bars exposed for 10 years at five outdoor and three indoor locations. These data were published as a part of the 1950 report of committee B-6. The remaining zinc and magnesium specimens will be left exposed until 1959, or a total of 20 years.

Committee B-7 on Light Metals and Alloys, Cast and Wrought—This committee is starting a test program to determine corrosion resistance of a number of aluminum and magnesium alloys. Exposure may begin before the end of 1951.

Committee B-8 on Electrodeposited Metallic Coatings—The committee is studying various types of chromate and phosphate treated zinc and cadmium coatings. Five types of chromate treatment are being studied in industrial and marine atmospheres, warehouse storage, 100 percent humidity, salt spray and water immersion. A section also has been organized to study and suggest testing methods for supplementary organic finishes on electrodeposited surfaces.

Subcommittee II on performance tests is continuing exposure tests on copper-nickel-chromium on high-carbon steel and electrodeposited lead on steel and the periodic removal of lead coated panels for steel weight loss and tension tests. Data will be published later.

Committee C-19 on Structural Sandwich Constructions—An atmospheric exposure test program will begin with collection of samples as soon as agreement is reached on basic considerations, such as size of sample.

Committee D-1 on Paint, Varnish, Lacquer and Related Products—The committee is continuing its study of dirt retention at certain sites by exposing painted wood and metal panels. Humidity and immersion testing also is continuing. Committee XXIX is initiating preparation of standards for ferrous surfaces for painting.

Committee D-14 on Adhesives—A program is under consideration to correlate laboratory accelerated test cycles and normal outdoor weathering and a study of methods for determining the corrosion resistance of adhesives is being contemplated.

The Electrochemical Society

Held a corrosion symposium at Buffalo, New York, October 11-13. The Cor-
(Continued on Page 20)

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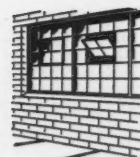
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Sixteen Inter-Society—

(Continued from Page 18)

rosion Division will sponsor another symposium in the fall of 1951 at Detroit, the topic of which is not announced.

A symposium on Electrode Kinetics was held April 8-11, 1951.

Mr. F. L. LaQue has been named chairman pro tem of the Corrosion Handbook Committee.

American Society for Metals

No corrosion research sponsored.

National Bureau of Standards

Study of corrosion in marine and other atmospheres, aircraft alloys in sheet form continued. Exposure of titanium and its alloys started. Progress reports made to sponsors of project and results published from time to time.

A report of F. M. Reinhart on exposure tests of galvanized steel-stitched aluminum alloys was submitted for publication by the National Advisory Committee for Aeronautics.

Work on underground corrosion has been curtailed to meet budget limitations. All specimens scheduled for removal in 1950 have been transported to the bureau but examination will be delayed because of personnel reductions.

Reports by I. A. Denison and M. Romanoff "Soil Corrosion Studies 1946—Ferrous Metals and Alloys" (PR 2057) were published. "Soil Corrosion Studies, 1946 and 1948—Copper and Copper Alloys, Lead and Zinc" (RP 2077) were published early in 1950.

Dr. Holler's considerations of the theoretical aspects of polarization, cathodic protection and related phenomena titled "Some Electrical Relations in Galvanic Couples" (RP 2148) was published by the Electrochemical Society.

Study of the variables in salt spray testing was resumed.

Experimental work on the corrosion of metals in housing exteriors was completed and a final report is being prepared.

A study of the fundamentals of stress corrosion is in initial stages.

American Chemical Society

No formal corrosion investigations.

Association of American Railroads

Engineering Division has two projects, one with protection of rail webs within joint bar limits. Periodical measurements have been made of a service test installation with various types of joint bar lubricants on the Burlington Railroad near Earlville, Ill. The installation has developed interesting and worthwhile data in five years.

Additional service tests on rail joint lubricants were made on the Illinois Central Railroad near Kankakee were instituted using new types of materials developed since the Earlville installation was placed.

The other corrosion research project pertains to corrosion from brine drippings. No work was done during the year on the project but work will be resumed soon.

National Research Council

Activity of the Division of Chemistry and Chemical Technology was confined to operations of the Prevention of Deterioration Center. It is concerned with deterioration of materials. It has agreed to act as a repository for data to be available for future revisions of the Electrochemical Society's Corrosion Handbook, for agencies of the Department of Defense and for publications desiring such information.

ECS Corrosion Handbook Committee

Steps were taken to reactivate the committee with the following immediate objectives:

1. Enlarge the number of media for which materials are rated, and particularly to attempt a more detailed breakdown of present groupings for which ratings are referred to some other media.
2. Enlarge the list of materials for which ratings are given.
3. Bring present ratings up to date.
4. Include more detailed explanation of the rating scheme.

Little progress has been made in persuading journals who regularly publish data of this sort to use records of the committee as a common source for the basic information they require.

American Society of Heating and Ventilating Engineers

No report to make on corrosion work.

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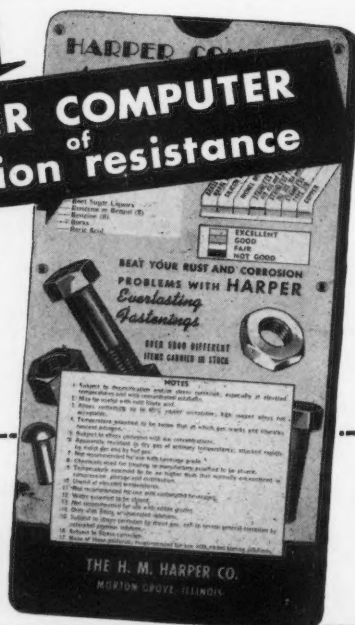
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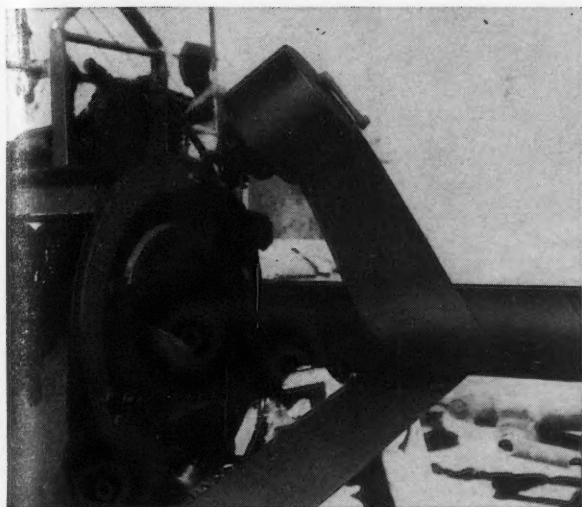
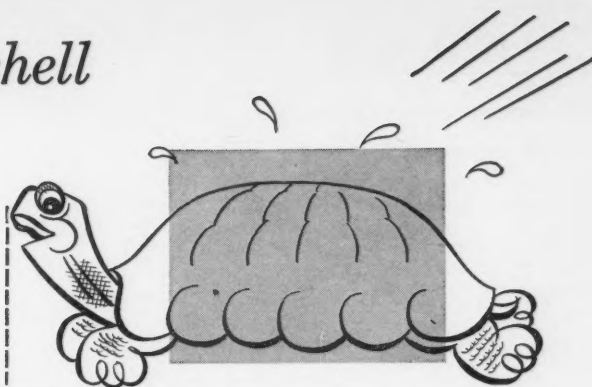


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For a handling charge of \$5 the National Association of Corrosion Engineers will ship postage paid to authors of technical material published in CORROSION, not earlier than six months after publication, printing plates used for figures in articles, NACE undertakes to ship such printing plates as are available, without warranty as to their condition or completeness. Those who wish to take advantage of this offer are asked to submit a request in writing, giving the issue in which the article in question was published, full address to which plates are to be shipped and billing information to:

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New Members and Changes of Address

(Changes through March 28, 1951)

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GLASGOW, ROBERT A., Casey & Case Coating Co., P. O. Box 151, Maywood, California.
GREEN, E. F., Axelson Mfg. Co., Box 15335 Vernon Station, Los Angeles 58, California.
PATTON, ARTHUR L., Long Beach Naval Shipyard, Seaside Blvd., Long Beach 2, California.
POPELAR, WALTER A., San Diego Gas & Electric Co., 175 11th St., San Diego, California.
RAASCH, DALLAS G., La Mesa, Lemon Grove, Spring Valley, Irrigation District, 4769 Spring St., La Mesa, California.
SHONAFELT, AUSTIN E., The Norwalk Co., Rosedale Highway, Bakersfield, California.

COLORADO

TAYLOR, ROBERT W., Standard Pipeprotection, Inc., 2380 Birch St., Denver, Colorado.

DELAWARE

GAMMACHE, ROBERT L., 514½ Mansion Rd., Elmhurst, Wilmington, Delaware.
KERN, GEORGE P., JR., Gates Engineering Co., P. O. Box 1711, Wilmington, Delaware.

ILLINOIS

BONNER, WILLIAM A., Shell Oil Co., Box 262, Wood River, Illinois.
HUNT, BILL E., Institute of Gas Technology, 17 West 34th, Chicago, Illinois.
MENSCH, HAROLD F., Pipe Line Service Corp., P. O. Box 218, Franklin Park, Illinois.
PROSSER, ROBERT A., Duriron Co., Inc., 208 S. La Salle St., Chicago, Illinois.
RISETTER, LEONARD O., Industrial Coatings Corp., 3227 S. Shields Ave., Chicago 16, Illinois.
SANDBORG, OGDEN W., Armour & Company, General Office, U. S. Yards, Chicago 9, Illinois.
SCHMIDT, BURTON J., The Tapecoat Co., 1521 Lyons, Evanston, Illinois.

INDIANA

SPRAUL, J. ROBERT, General American Transportation Corp., 300 W. 151 St., East Chicago, Indiana.

IOWA

HILL, WALLACE T., 524 Marion St., Boone, Iowa.

KANSAS

PAYNE, PHIL R., Union Gas System, Inc., Independence, Kansas.
WHITE, W. J., The Kansas Power & Light Co., 116-118 West Iron Ave., Salina, Kansas.

LOUISIANA

JAHNKE, LOUIS P., Ethyl Corp., P. O. Box 341, Baton Rouge, Louisiana.
MILTENBERGER, GUSTAVE, Southeast Distributors, Inc., 636 Carondelet St., New Orleans, Louisiana.
MITCHELL, RICHARD E., Shell Oil Co., P. O. Box 193, New Orleans, La.
WATERFIELD, JOSEPH H., United Gas Corp., 113 Harrison, Monroe, Louisiana.
WHITEHEAD, ALLEN H., Metal Goods Corp., 432 Julia St., New Orleans, Louisiana.

MARYLAND

GORDON, MAURICE B., Consolidated Gas & Electric Co. of Baltimore, Baltimore, Maryland.
MANNING, THOMAS H., U. S. Industrial Chemicals, Inc., P. O. Box 1956, Baltimore 3, Maryland.

MASSACHUSETTS

FISHER, A. ORMAN, Monsanto Chemical Co., Chemical Lane, Everett 49, Massachusetts.

MICHIGAN

RUNSER, SKYLES, E. JR., Michigan-Wisconsin Pipe Line Co., 500 Griswold, Detroit 26, Michigan.

MISSISSIPPI

CASANOVA, OTIS B., Rust-Oleum Corp., Deer Creek Dr., Rolling Fork, Mississippi.

MISSOURI

ELLWOOD, EDWARD E., Steel Sales Corp., 1575 McRee St., Louis 10, Missouri.
ISAACKS, ALBERT N., 128 West Southside Blvd., Independence, Missouri.
KELLER, WAYNE H., Mallinckrodt Chemical Works, 65 Destrehan, St. Louis 7, Missouri.
VON MEYER, WILLIAM H., Barry-Wehmiller Machinery Co., 4660 Florissant, St. Louis 15, Missouri.

NEW JERSEY

ADAMS, HENRY W., Amercoat Corp., 29 New York Ave., Newark 5, New Jersey.
BICK, MAURICE, Fidelity Chemical Products Corp., 470-474 Frelinghuysen Ave., Newark 5, New Jersey.
DRAGOSSET, WM. H., 36 Chase Ave., Avenel, New Jersey.
KEENAN, KATHLEEN, Celanese Corp. of America, Norris Court, Summit, New Jersey.
PANEK, JULIAN R., Thikol Corp., 780 N. Clinton Ave., Trenton, New Jersey.
TUNDERMANN, WERNER O., Box 63, RFD 2, Rahway, New Jersey.
WALTON, ROBERT J., 3rd., Electro Rust-Proofing Corp., 1 Main St., Belleville 9, New Jersey.

NEW YORK

CARTER, NELSON B., Eastman Kodak Co., Kodak Park Works, Bldg. 23, Rochester, New York.
CLEMENT, ALBERT J., Ebasco Services, Inc., 2 Rector St., New York, New York.
DE WALTOFF, LIONEL, Chemelean Products Corp., 58 Watts St., New York 13, New York.
ERGUL, NECDET F., Long Island Lighting Co., 250 Old Country Rd., Mineola, Long Island, New York.
FRENCH, JAMES B., 2nd, French Mill Supply Corp., 640 Varick, Utica, New York.
HICKS, CHARLES P., Ebasco Services, Inc., 2 Rector St., New York 6, New York.
HOOVER, MORGAN M., Chemical Engineering, McGraw-Hill Pub. Co., 330 W. 42nd St., New York 18, New York.
JACKSON, ROBERT M., Distillation Products Industries, 755 Ridge Road West, Rochester 13, New York.
McDONOUGH, WILLIAM D., American Cyanamid, Lederle Lab. Div., Pearl River, New York.
McNAMARA, AMBROSE, J., North & Judd Mfg. Co., 71 W. 23rd St., New York, New York.
MADIGAN, JAMES F., Works Lab., Sperry Gyroscope Co., Great Neck, New York.
ROEDER, GEORGE F., 437 Washington Highway, Buffalo 21, New York.
STETSON, RICHARD W., Dowell, Inc., 45 Rockefeller Plaza, New York, New York.
STEWART, ISAAC, New York Testing Laboratories, Inc., 80 Washington, New York 6, New York.

NORTH CAROLINA

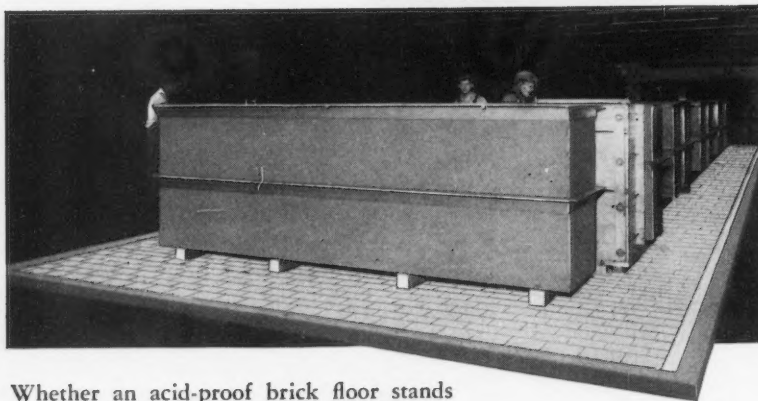
BROWN, B. F., Engineering Research Dept., N. C. State College, Raleigh, North Carolina.
BURDITT, GEORGE F., American Wheel-laborator & Equip. Corp., 211 West Sycamore, Greensboro, North Carolina.

OHIO

FISHER, JOHN R., JR., Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio.

(Continued on Page 24)

FOR LESS MAINTENANCE OVERHEAD put Durisite and Brick UNDERFOOT



Whether an acid-proof brick floor stands up year after year without high maintenance costs depends mostly on the joints between the bricks. The thinner the joint the better the chance for long, trouble-free life. But with ordinary bonding mortars you can't get a joint much thinner than 1/4".

Durisite acid-and-alkali-proof cement, however, bonds brick double-tight with extra thin joints . . . 3/32" or less. Not only does Durisite make a thin, strong joint, but it makes a dense, non-absorbent joint.

Durisite is a resin-type cement, sets quickly by internal chemical reaction, is non-toxic, non-explosive, non-inflammable.

U. S. STONWARE

PROCESS EQUIPMENT DIVISION, AKRON 9, OHIO

FOR A FLOOR
YOU CAN INSTALL,
AND FORGET,
INSIST ON
"U.S." TRIPLE-
CONSTRUCTION



4" to 6" rigid
concrete sub-
base

Resilon cor-
rosion - resistant
protective mem-
brane

"USSCO" Acid
Brick bonded
with double-
tight, Durisite
thin joints.

The U. S. Stoneware Co. can supply all necessary materials for installation by your own workmen of a "triple-construction" acid-and-alkali-proof floor, or if you desire, we can handle the entire job, including labor and materials.

10 SOUND REASONS

FOR PROTECTING YOUR PIPELINES WITH BARRETT* COAL-TAR COATINGS



THE BARRETT DIVISION

ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N.Y.

- 1 **BARRETT coal-tar enamels** and application procedures are available for every pipe-coating use in the oil and gas field, and for use under all types of climatic conditions and topography.
- 2 **Barrett makes coal-tar enamels** in grades that will not crack at -20°F. , nor flow at 160°F.
- 3 **BARRETT coal-tar enamels** possess high ductility and flexibility in all grades, and show high resistance to soil stresses.
- 4 **BARRETT coal-tar coatings** adhere closely to the pipe, and are not damaged by "breathing," nor by deflectional stresses caused by loading of the back-fill.
- 5 **BARRETT coal-tar enamels** have high dielectric properties—require less "outside" current to make cathodic protection effective.
- 6 **BARRETT coal-tar enamels** are impermeable to moisture.
- 7 **BARRETT coal-tar enamels** are resistant to attack by gas and petroleum products.
- 8 **Another advantage** of BARRETT coal-tar coatings is the widespread experience of the engineers and contractors who have worked with them.
- 9 **Also, their universal availability** and ease of application, through applicators all over the country.
- 10 **And last, but not least**, the Barrett organization is always at your disposal to advise on materials and on application procedure, and to consult with you on any pipe-coating problem.

New Members—

(Continued from Page 22)

GOODMAN, WINKLER W., Chemical Fireproofing Corp., 1629 Walnut St., Cincinnati 10, Ohio.

OKLAHOMA

ALLEN, CLYDE C., Anderson-Prichard Oil Corp., R & D, Cyril, Oklahoma.
ANDERSON, FRANCIS M., Halliburton Oil Well Cementing Co., 1015 Bois D'Arc, Duncan, Oklahoma.
COULSON, H. M., Sinclair Oil & Gas Co., Gasoline Dept., Box 521, Tulsa 2, Oklahoma.
TRAPP, RAYMOND F., Midwestern Engine & Equipment Co., 105 N. Boulder, Tulsa, Oklahoma.
VERNOOY, B., 4014 E. Virgin Pl., Tulsa 10, Oklahoma.

PENNSYLVANIA

BELLOWS, WILLIS A., Rust-Oleum Corp., 21 N. Hill Dr., West Chester, Pennsylvania.
BIGOS, JOSEPH, Steel Structures Painting Council, Mellon Institute, 4400 Fifth Ave., Pittsburgh 17, Pennsylvania.
DAUB, WALTER H., JR., Pittsburgh Coke & Chemical Co., 1905 Grant Bldg., Pittsburgh, Pennsylvania.
MCIPHERSON, JOHN L., 301 Griffin Ave., Pittsburgh 10, Pennsylvania.

TENNESSEE

SELLERS, WILLIAM N., Amer. Bemberg, Elizabethton, Tenn.

TEXAS

BARFIELD, JOE W., Southern Pipeline Corp., P. O. Box 716, Corpus Christi, Texas.
BLISS, AMES, Cameron Iron Works, Inc., P. O. Box 1212, Houston 1, Texas.
EVANS, ROBERT L., JR., Houston Lighting & Power Co., Electric Bldg., Houston, Texas.
GREENE, CLIFFORD A., Goodyear Tire & Rubber Co., 3809 Parry Ave., Dallas, Texas.
KIRKPATRICK, JAMES L., Minnesota Mining & Mfg. Co., 212 S. St. Paul St., Dallas, Texas.
KNOX, JOHN A., The Western Co., Box 310, Midland, Texas.
LINDSAY, J. D., Chemical Engineering Dept., A. & M. College of Texas, College Station, Texas.
SIMS, JOHN J., D. W. Haering & Co., Inc., Box 105, Station 1, Canyon, Texas.

TAYLOR, WILLIAM R., City Gas Div., City Hall, Corpus Christi, Texas.
WILSON, CHARLES H., Consolidated Chemical Industries, Inc., P. O. Box 5275, Houston, Texas.
WINTLE, JAMES V., JR., Texas Pacific Coal & Oil Co., P. O. Box 393, Midland, Texas.

FOREIGN CANADA

CRUMBACK, A. LLOYD, Canadian Equipment Sales & Service Co., Ltd., 7310-99th, Edmonton, Alberta, Canada.
MAGGIACOMO, SAM, General Flooring Co., 3583 Dundas St., W., Toronto, Canada.

ENGLAND

MOHR, BERNARD H., Windsor & Co., Ltd., Scrubbs Lane, London N. W. 10, England.

CHANGES OF ADDRESS

(Old address follows new in parenthesis)

ARKANSAS

OLSON, THEODORE W., Texas Illinois Natural Gas Pipe Line Co., Box 788, Little Rock, Arkansas. (Texas Illinois Natural Gas Pipe Line Co., General Delivery, Wharton, Texas.)

CALIFORNIA

DAVIE, FRANK E., 1008 W. Sixth St., Los Angeles 14, California. (Shell Oil Co., P. O. Box 329, Tracy, California.)
HALSTED, HAL P., Reed-Halsted & Co., P. O. Box 314, Altadena, California. (Reed-Halsted & Co., 2020 N. Lake, Altadena, California.)
KEELING, HARRY J., Southern Counties Gas Co. of California, 810 S. Flower, Los Angeles 17, California. (Southern Counties Gas Co. of California, 810 S. Flower, Los Angeles 14, California.)
MCCOMAS, JOHN Q., P. O. Box 1078, Beverly Hills Post Office, Beverly Hills, California. (Permolite, Inc., N. 5th & Ford Blvd., Hamilton, Ohio.)

CONNECTICUT

MITCHELL, N. W., Chase Brass & Copper Co., 236 Grand St., Waterbury 20, Connecticut. (Chase Brass & Copper Co., 236 Grand St., Waterbury 91, Connecticut.)
VANDERPOOL, HOWARD, Metallizing Engineering Co., 1039 State St., Bridgeport 5, Connecticut. (Metallizing Engineering Co., 401 S. 16th St., Philadelphia 46, Pennsylvania.)

COLORADO

HOPKINS, JOHN R., Protecto Wrap Co., P. O. Box 82, Englewood, Colorado. (The Tapecoat Co., 175 Niagara, Denver, Colorado.)

ILLINOIS

BUETTNER, WALTER J., Plastic Lining Corp., 900-902 S. Wabash Ave., Chicago 5, Illinois. (Plastic Lining Corp., 914 S. Wabash Ave., Chicago, Illinois.)
FOELSCH, HENRY W., 1802 W. Byron St., Chicago 13, Illinois. (Stalpic Coating Corporation, 2310 S. Indiana Ave., Chicago 16, Illinois.)
TERRILL, J. MARK, 1520 N. Halsted, Chicago 22, Illinois. (Quartex Corp., 1357 Sedgwick, Chicago 10, Illinois.)
UNDERWOOD, O. G., 7500 S. Shore Dr., Chicago, Illinois. (429 Forrer Blvd., Dayton, Ohio.)
VAN NATTA, C. A., Plastic Lining Corp., 900-902 S. Wabash Ave., Chicago, Illinois. (Plastic Lining Corp., 914 S. Wabash Ave., Chicago, Illinois.)

INDIANA

MERWIN, WALTER J., R. R. No. 1, Cedar Lake, Indiana. (Institute of Gas Technology, 3300 S. Federal St., Chicago 16, Illinois.)

KANSAS

BROOKS, RICHARD H., JR., National Tank Co., Box 697, Wichita, Kansas. (Enardo Mfg. Co., 2729 Sand Springs Rd., Tulsa, Oklahoma.)
PEARL, JAMES C., Service Pipe Line Co., Box 519, Topeka, Kansas. (Service Pipe Line Co., Box 591, Scottsbluff, Nebraska.)

LOUISIANA

HALL, W. QUENTIN, 2176 Ferndale Ave., Baton Rouge 6, Louisiana. (Ethyl Corp., Baton Rouge, Louisiana.)
O'BRIEN, PAUL S., 2140 Terrace Ave., Baton Rouge 6, Louisiana. (Socony Paint Products Co., 726 Westmoreland Dr., Baton Rouge 6, Louisiana.)
WALKER, JACK R., 227 E. Slattery, Shreveport, Louisiana. (United Gas Pipe Line Co., P. O. Box 1407, Shreveport, Louisiana.)

MICHIGAN

YOUNGER, A. M., c/o G. Gwin, Route 2, Paw Paw, Michigan. (463 Munich St., San Francisco, California.)

MISSISSIPPI

SWINDOLL, ROBERT E., United Gas Corp., P. O. Box 1138, Jackson, Mississippi. (United Gas Corp., Laurel, Mississippi.)

NEW JERSEY

EDDISON, CLIFFORD, RCA Victor Div. Radio Corp. of Am. Chemical & Physical Laboratories, Bldg. 7-4, University St., Jersey City, N. J. (RCA Victor Div. Radio Corp. of Am. Chemical & Physical Laboratories, Camden, New Jersey.)

NEW YORK

HEALEY, EDWARD LEWIS, 58 Greeley Ave., Sayville, New York. (269 Candee Ave., Sayville, New York.)
HENDERSON, WALTER A., New York Telephone Co., 140 West St., Room 1513, New York 7, New York. (New York Telephone Co., 140 West St., Room 1323, New York 7, New York.)
JORDAN, HARRY E., Amer. Water Works Ass'n., 521 Fifth Ave., New York 17, New York. (Amer. Water Works Ass'n., 500 Fifth Ave., New York 18, New York.)

OHIO

McGLOTHLIN, BRUCE B., JR., University of Cincinnati, 139 West University St., Cincinnati 19, Ohio. (University of Cincinnati, 2829 Scioto St., Cincinnati 19, Ohio.)
PRENDERGAST, PHILIP J., The Cellicote Co., 4832 Ridge Rd., Cleveland 9, Ohio. (The Cellicote Co., 750 Rockefeller Bldg., Cleveland 14, Ohio.)
RICE, S. S., Ekco Products Co., Massillon Aluminum Div., Massillon, Ohio. (The Ohio Brass Co., North Main St., Mansfield, Ohio.)

OKLAHOMA

LADD, GLENN L., Sinclair Oil & Gas Co., Box 1070, Seminole, Oklahoma. (Sinclair Oil & Gas Co., Box 521, Tulsa, Oklahoma.)

TENNESSEE

BRASUNAS, ANTON DESALES, 111 E. Geneva Lane, Oak Ridge, Tennessee. (c/o General Delivery, Oak Ridge, Tennessee.)

TEXAS

ASHWORTH, JAMES ELMO, 163 Orr Rd., El Paso, Texas. (2290 San Jose St., El Paso, Texas.)
DOSS, GLENN K., 1007 S. 13th St., Longview, Texas. (Standard Oil Dev. Co., 768 E. 2nd Ave., Roselle, New Jersey.)
EDWARDS, W. H., 5204 Elm St., Bellaire, Texas. (The Texas Co., Box 425, Bellaire, Texas.)
FARLEY, ELDEN R., Farley Co., Inc., 568 M & M Bldg., Houston 2, Texas. (Farley Co., Inc., 526 M & M Bldg., Houston 2, Texas.)
HART, PORTER, The Dow Chemical Co., Freeport, Texas. (The Dow Chemical Co., 1410 W. 4th St., Freeport, Texas.)
HODSON, FRED W., Johns-Manville Sales Corp., 401 N. Topcuhua St., Room 109, Corpus Christi, Texas. (Johns-Manville Sales Corp., P. O. Box 2366, Corpus Christi, Texas.)
HOLT, JAMES B., 2014 W. Melbourne St., Dallas 8, Texas. (625 W. Centre St., Dallas, Texas.)
KLINGER, O. C., 101 West Alabama, Houston, Texas. (Oilfield Publishing Co., 1217 Hudson County Blvd., Bayonne, New Jersey.)
MEEK, J. GORDON, Metal Goods Corp., P. O. Box 7086, Dallas 9, Texas. (Metal Goods Corp., P. O. Box 7223, Dallas 9, Texas.)
POOL, JOHN L., Magnolia Pipe Line Co., 501 Magnolia Bldg., Box 900, Dallas, Texas. (Magnolia Pipe Line Co., 618 Magnolia Bldg., Box 900, Dallas, Texas.)
RAINEY, JOHN B., 216 Mulford, Houston 6, Texas. (Mission Mfg. Co., P. O. Box 4209, Houston 5, Texas.)
REEVES, B. M., 2202 Pine Crest Dr., Marshall, Texas. (Route 2, Box 216 Marshall, Texas.)
RHODES, H. A., Transcontinental Gas Pipeline Corp., 2100 Nells Esperson Bldg., Houston, Texas. (Fish Constructors, 1090 M & M Bldg., Houston 2, Texas.)
SHEETS, MACON, Nueces Painting Co., P. O. Box 4018, Corpus Christi, Texas. (Nueces Painting Co., P. O. Box 4071, Corpus Christi, Texas.)
SLAVIK, EDWARD W., Dowell Inc., 1108 Wilson Bldg., Corpus Christi, Texas. (Dowell Inc., 307 California Co. Bldg., New Orleans, Louisiana.)
TUGGLE, LAYTON C., 1306 Richard St., Pasadena, Texas. (Shell Oil Refinery, P. O. Box 2527, Houston 1, Texas.)
WEAVER, JAMES E., Weaver Equipment & Supply Co., 4139 Southwestern, Houston 5, Texas. (Weaver Equipment & Supply Co., 1816 Pierce, Houston, Texas.)
WELSH, MYRON E., National Bulk Carriers, Inc., 5520 Truett St., Houston 23, Texas. (National Bulk Carriers, Inc., 5520 Truett St., Houston 5, Texas.)

WISCONSIN

BOST, ARMON H., Colonel, 306th Logistical Command, Camp McCoy, Wisconsin. (Midwestern Engine & Equip. Co., Inc., 105 North Boulder, Tulsa, Okla.)

(Continued on Page 25)

PLASTIC COATINGS

Vinyl and phenolic coatings, flame sprayed polyethylene and special cement linings, for protection against corrosion and/or contamination. Applications made in our plant or in the field to processing, storage and transportation equipment for oil, food, water, chemical and allied industries.



Other Metalweld services include Rubber and Koroseal lining, Metallizing, Sand Blasting and Welding. Inquiries are invited. Write for Bulletin (A).

Metalweld INC.

26th & HUNTING PARK AVE.
PHILADELPHIA 29, PA.

New Members—

(Continued from Page 24)

**FOREIGN
CANADA**

SHAW, GEORGE S., 14 Hemlock Ave., Shawinigan Falls, P. Q., Canada. (Shawinigan Chemicals Ltd., Library, Shawinigan Falls, P. Q., Canada.)
 EVANS, DAVID H., British American Oil Co., Ltd., 800 Day St., Toronto, Ontario, Canada. (British American Oil Co., Ltd., Box 460, Terminal A., Toronto, Ontario, Canada.)

COLOMBIA

LOWE, MARVIN E., Texas Petroleum Co., Apartado Postal 159, Barranquilla, Colombia, S. A. (Texas Petroleum Co., Apartado Postal 877, Bogota, Colombia, S. A.)

**NEW CORPORATE
MEMBERS**

The following firms have joined the National Association of Corrosion Engineers since compilation of the list published in March, 1951, as part of the annual directory of membership:

AMERICAN CAN COMPANY

Maywood, Illinois

Dr. L. P. Gotsch, Representative

AMERICAN TOBACCO COMPANY

Richmond, Virginia

R. Peele Hackney, Representative

AXELSON MANUFACTURING CO.

Los Angeles, California

E. F. Green, Representative

CASEY & CASE COATING COMPANY

Maywood, California

Robert A. Glasgow, Representative

COOPER-BESSEMER CORPORATION

Mount Vernon, Ohio

H. A. Gehres, Representative

CROWN CENTRAL PETROLEUM CORP.

Houston, Texas

H. S. Lane, Representative

CRUCIBLE STEEL CO. OF AMERICA

Pittsburgh, Pennsylvania

E. W. Hopper, Representative

**HALLIBURTON OIL WELL CEMENT-
ING COMPANY**

Duncan, Oklahoma

Francis M. Anderson, Representative

KANSAS POWER & LIGHT COMPANY

Salina, Kansas

W. J. White, Representative

OIL WELL SUPPLY COMPANY

Oil City, Pennsylvania

F. Lee Current, Representative

RHEEM MANUFACTURING COMPANY

South Gate, California

Ralph Gieser, Representative

SINCLAIR OIL & GAS COMPANY

Tulsa, Oklahoma

H. M. Coulson, Representative

TUSCARORA OIL COMPANY, LTD.

Harrisburg, Pennsylvania

John W. deGroot, Representative

WYATT METAL & BOILER WORKS

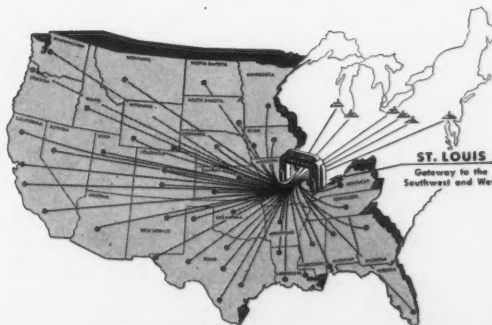
Houston, Texas

C. A. Haas, Representative

**20,000** □'**FINAL INSPECTION AREA**

STANDARD'S PROCEDURE . . . requires your coated and wrapped pipe to be electrically inspected . . . every piece . . . 20,000 sq. ft. area exclusively used for the industry's most modern final inspection . . . the pipe is moved to the loading area on canvas covered, sponge-rubber padded skids . . . long enough so that the applied coatings have more than enough time to properly cool, to prevent any thinning out or damage in handling and loading.

COATING AND WRAPPING-IN-TRANSIT . . . permits stop-off for processing or storage at St. Louis without freight penalty. When you ship through the St. Louis gateway, you enjoy "through freight rates" instead of the higher combination rates generally used.



New Catalogue
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**Corrosion
News Deadline:
10th of Month
PRECEDING
Date of Issue**

NEW PRODUCTS — Materials — Service — Literature

Bakelite coatings for protection and decoration of all types of surfaces are described in a 28-page booklet offered by Bakelite Company, a Division of Union Carbide and Carbon Corp. Copies may be secured by business executives on request from the company's offices, Dept. 1503, 300 Madison Ave., New York 17, N. Y.

Precision platinum thermometer for high temperatures will make precision measurements to 1400 degrees C and remain operative at 1600 degrees C. It is mounted in a stainless steel tube for temperatures up to 1000 degrees C and in ceramic tubes for higher temperatures. It is supplied with 4 leads. The ice point resistance is 10 ohms. Universal Speed Bridge Thermometers, a self-contained pyrometer or thermometer that can be plugged into any 60 cycle 115 v line, covers a range from 200 degrees C to 1600 degrees C with two types of bulbs. Manufacturers are Weiller Instrument Corporation.

American-Marietta Co., 43 East Ohio St., Chicago, 11, Ill., has purchased approximately 53 percent of the outstanding common shares of Metals Disintegrating Co., Inc., Elizabeth, N. J. manufacturer of metal powders.

Koppers Company has initiated a program to expand its chemical division through construction of a new plant near Port Arthur, Texas, and additions to its present facilities at Kobuta, Pa. The program will in a year make possible increase of the company's production of styrene monomer about 33 percent and increase production of polystyrene about 25 percent. The Port Arthur plant will produce ethylbenzene from ethylene from the Gulf Oil unit to be built at its Port Arthur refinery.

Fire-Gard finishes for application to metal surfaces subjected to temperatures ranging from 500 degrees F to 1500 degrees F and manufactured by Fire-Gard, Inc., 1424 K Street N. W., Washington 5, D. C. The company also makes fire retardant paints for wood.

Steel Strapping material can be dispensed from a motorized dispenser developed by A. J. Gerrard & Co., Melrose Park, Ill. The machine uncoils the strap along the floor so when the desired length is unrolled the operator may cut it off with a manually operated shear.

Vapor-Tight electric lighting fixtures made of Alomalloy, are available in one-piece and assembled styles. Die-cast fittings of aluminum alloy also are available. Both are recommended for electrical installations in the petroleum and processing industries where their special characteristics are useful, by Killark Electric Manufacturing Co., Vandeventer and Easton Ave., St. Louis 13, Mo.

Cathodic Protection of Surface Condensers, Vol. 2, No. 1, The Magnesium Anode, by Dowell Incorporated, Tulsa 3, Okla., describes methods and gives design criteria and installation instructions

for applying cathodic protection with magnesium anodes to surface condensers.

Bulletin 3081, a check chart to help guard against rust invasion is available from Dearborn Chemical Co., 310 S. Michigan Ave., Chicago 4, Ill. The chart is a plant diagram showing vulnerable spots where rust is most likely to occur.

Data Sheets on two Vibroground ground and soil resistivity testing instruments Models 243 and 263 are available from Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.

Alnico replacement magnets for pipeline trap separators are available from Eriez Manufacturing Co.

Standard Pipeprotection, Inc., 3000 South Brentwood Blvd., St. Louis 17, Mo., has issued a new brochure on its pipe coating services. One feature of interest is a graphic representation of four types of standard specifications.

Dowell Incorporated has opened a new district laboratory at Midland, Texas. J. O. Means, formerly at Tulsa has been put in charge.

Two Solutions can be sprayed at one time from a new type gun now being marketed by Schori Process Division, Ferro-Co Corp., 8-11 43rd Road, Long Island City 1, N. Y. The gun was developed to handle materials stable in themselves that cure quickly only when mixed with other materials. Formulations can be sprayed that will be tack free in 10 minutes. The unit uses two pots and a gun with two nozzles. Materials are mixed "externally" when atomized. Marco resins developed specially for use with the new gun are available at Schori.

Paracetic Acid—a Bactericide-Fungicide, a new bulletin by Buffalo Electro-Chemical Co., Buffalo, N. Y. gives complete details on the use and application of Becco Paracetic Acid in the food industry. Novel features of the material recommend it for germicidal washing of fruits and vegetables and for equipment sanitizing. Write to Becco Sales Corp., Station B., Buffalo 7, New York, to secure a copy of the bulletin.

NuKast Pumps and Heat Exchangers for transfer of hot or cold corrosive liquids are made of cast resins with no metal in contact with solutions. The pump stuffing box is eliminated, and transfer range is up to 100 gpm at varying heads. Literature is available from Nukem Products Corp., Buffalo 20, N. Y.

Metal Protective Red Lead Paints by C. J. Vander Valk of Lead Industries Association, a reprint from Vol. 41, No. 1, Paint and Varnish Production, is available from the association, 420 Lexington Ave., New York City.

Sola Catalytic Process, a proprietary process of the Sola Catalytic Company,

520 Browder St., Dallas 1, Texas, is a water treatment method said by the manufacturer to accomplish the following: Cleans piping and tanks by eliminating hard and soft precipitates, removes and reduces further formation of corrosion, eliminates the odor of chlorination, eliminates the need for dosing and periodic analysis and control required when chemical softeners and de-scalers are used, and other benefits. These results are achieved, the company states, by a catalytic process which produces a variable magnetic field in the water passing through the apparatus which has the power of converting unstable parahydrogen to orthohydrogen. The active portion of the device is a hermetically sealed tube holding the active ingredients. These tubes are inserted in the apparatus in such a way the incoming, cold, untreated water moves around the tubes. The benefits acquired by the water are effective at considerable distances from the point of treatment, and the application is cyclic: For two consecutive days the device is valved into the water line and for five consecutive days it is valved out of the water line. Water treated by the process should not be recirculated and this necessitates placing the device on the raw feed line only. Models of various sizes are made, including one for domestic water systems. The tube containing the active ingredient must be replaced at six month intervals. Life of the tubes apparently is not related to the volume of water treated, the firm's literature intimates. Further information and illustrated literature may be secured from the manufacturers.

Pyrene Manufacturing Co. has removed its finishing division to 10 Empire St., Newark, N. J., Processes available at the plant include Alumilite, Bond-erite, Parco Lubrizing, Parkerizing, Pyrene bright nickel plating, chromium plating, hard chromium plating, Pylumin, Iridite, Cronak, lead plating, cadmium plating, bright zinc plating, Pyron and others.

Natural Rubber, Neoprene and plastic industrial gloves are described in a 4-page folder available from American Rubberizing Co., 617 Eleventh Ave., Minneapolis, Minn.

Durable Bright finishes without copper or nickel can be produced by several systems developed by United Chromium, Inc., 100 East 42nd St., New York 17, N. Y. One produced with zinc plate involves use of Unichrome Clear Dip and Baking Synthetic B-115. With eye-appeal similar to chromium, it possesses the well-known anti-rusting characteristics of zinc. Another finish is produced on steel with chromium plated on the basis metal and coated with a clear baking synthetic. On zinc die castings, a buffing operation is necessary.

Monsanto Chemical Company is negotiating for the purchase of a 115-acre site and several buildings in Addyston, Ohio, as a Midwestern center for production and distribution of plastics.

(Continued on Page 27)

New Products—

(Continued from Page 26)

Abutting the city limits of Cincinnati, the plant will be operated as a part of the company's plastics division by F. A. Abbiati, division general manager. Initial production at the new plant will be styrene molding materials and phenolic resins.

Non-Ferrous and **Stainless Steel** alloys to use for 142 corrosive situations are listed on a pocket size computer available from H. M. Harper Co., 8200 Lehigh Ave., Morton Grove, Ill. It operates like a slide rule, the inner member being moved to line up the corrosive agent with a large arrow. A window then rates 13 non-ferrous and stainless steel alloys as excellent, good, fair or not good for this agent.

Neoprene now is available for application as an airdry protective coating, according to DuPont Product Information Service. The material, produced by Gates Engineering Company, Wilmington, Del., has been named Gaco Neoprene Maintenance Coating. An outstanding feature of the new coating is that it develops its desirable physical characteristics without heat. The coating is not subject to embrittlement by volatilization or displacement of a plasticizer because it contains no plasticizer. Surface preparation need not include sandblasting—wirebrushing and degreasing usually proving sufficient to assure satisfactory bond.

Brooks Chemicals, Inc., is the new name chosen for Brooks Boiler Treatment Co., 3304 East 87th St., Cleveland 27, Ohio.

"**Immunol**" a proprietary compound of Haas Miller Corp., 4th and Bristol St., Philadelphia 40, Pa., is recommended by the manufacturer for the following uses, among other things: It "immunizes" water against rust, preventing the formation of rust where it has not begun already, but it will not remove rust once it has started; air dried it forms a rust preventive coating on metals; it is a powerful detergent useful for cleaning parts, machines, walls and floors, but it contains no soaps or alkalis which affect the skin. The coating left after air drying can be washed off easily with plain water, but need not be removed for subsequent painting or finishing operations.

Babcock & Wilcox Tube Co., Beaver Falls, Pa. offers its Technical Bulletin 19 containing technical data on stainless steel tubing including analyses, oxidation resistance, thermal treatment and mechanical, electrical and physical properties on ten of the most popular austenitic and ferritic stainless tubing steels.

Synthetic Rubber based corrosion control coatings—machinery enamels, damp-wall enamels, cement floor finishes and stucco-masonry coatings produced by Casey & Case Coating Co., P. O. Box 151, Maywood, Cal. are described in a brochure available from the company.

Corson-Cerveney Micro-Bellows Pump is described in a pamphlet by Research Appliance Co., Box 413 West View Road, Pittsburgh 9, Pa. Parts exposed to pumped liquid are stainless steel, and the machine includes no packing, gasket

material, or pipe compounds of any sort. The bellows of the pump is actuated by an eccentric operating through a pivoted arm. Degree of bellows actuation is controlled by an adjustment of the arm which limits the action of the bellows post.

Exhaust Fan designed for handling sulfuric acid fumes is manufactured by International Engineering, Inc., Dayton, Ohio.

Elkote, a proprietary ceramic coating for metals and alloys resistant to oxidation, flexing, vibration, percussion and severe thermal shock has been developed by Elraco Engineering Co., 158 Fourteenth St., Hoboken, N. J. The material, manufacturers say, is a barrier against corrosion at temperatures up to 2400 degrees F. Metals protected by the coating heated to 1700 degrees F and plunged into water have been removed with the coating intact. The company will coat and return for test without cost or obligation metal samples submitted to it.

Federated Metals Division, American Smelting & Refining Co., has completed a new office building at 9000 Market Street Road, Houston, Texas.

Six Coal Tar Base anti-corrosive coatings have been developed by Continental Coatings Corp., 30 West 44th St., New York 19, N. Y., and South River, N. J. Non-soluble in oil and waterproof, they resist strong inorganic acids and alkalis. Three of the coatings are designed to resist corrosive conditions in combination with abrasion, vibrations and extreme contractions and expansions. No primer is needed, manufacturers state.

Nicolet Industries, Inc. (Formerly GAMA Industries) will call its asbestos felt Nicolet Asbestos Pipe Line Felt. The firm also manufactures other as-

bestos products and many metal products through associated companies.

"**Flexon**" Bellows, Bellows Assemblies and Bellows devices are described in an 18-page pamphlet by Chicago Metal Hose Corp., Maywood, Ill.



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can be stopped!!

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by W. A. Riley

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PERSONALS

C. A. Bauer of Commonwealth Edison Co., Chicago, Ill., has been appointed Supervising Engineer of the work of the Line Rating and Temperature Control Group and Corrosion and Electrolysis Control Group, reporting to W. H. Salle, Section Engineer in charge of the Underground Section.

John F. Thompson has been elected chairman of the board of International Nickel. Paul D. Mericka, executive vice-president was elected a member of the executive and advisory committees.

Frederick J. Griffiths of Massillon, Ohio, has been elected to the Follansbee Steel Corp. board of directors.

Norman W. Calkins has been named manager of tool steel sales and Harold A. Brossman manager of alloy steel sales by the Carpenter Steel Co., Reading, Pa.

Edwin Verecke has been appointed sales manager of Heil Process Equipment Corp., Cleveland, Ohio.

Guy F. Williams, has been promoted to sales manager of the Oil Field Products Division of Dowell Incorporated, Tulsa, Okla.

R. A. Colton and D. L. LaVelle, research metallurgists of Federated Metals Division, American Smelting and Refining Co., delivered a talk before the American Foundrymen's Society at Muskegon, Mich., April 2, on recommended melting and gating practices, causes of defects in aluminum and copper-base castings.

William H. McKenna has been elected vice-president of Hanlon-Gregory Galvanizing Co.

Ernest R. Mueller has been appointed supervisor of organic coatings research at Batelle Institute, Columbus, Ohio. He will be in charge of the fundamental and applied research on paints, varnishes and lacquers.

W. H. Dickinson and G. P. Longabaugh have been named to new posts in the Headquarters Manufacturing Division of Westinghouse Electric Corp.

Dearborn Chemical Co., Chicago has made the following personnel changes: C. S. White will head the water treatment department and Howard E. Johnston will be manager of No-Ox-Id sales for the Eastern Division. R. O. Benson has been assigned to the Iowa territory; C. R. Oller has returned to the San Francisco office; C. C. Dennis has been transferred to the Chicago sales staff replacing Vincent P. Nobile, assigned to the New Jersey territory. Paul E. France also has been added to the Chicago staff, R. H. Derr, Pittsburgh; M. H. Jamison, Chicago; W. M. Morris, Pennsylvania; V. E. Stiers, Oregon and T. Zaggy, Chicago. Veteran employees who have retired are S. H. Opdyke, C. I. Loudenback, M. M. Kutzer, B. E. Conley.



Corrosion Abstracts

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* PAGINATION OF CORROSION ABSTRACTS

Two numbers appear on each page of Corrosion Abstracts. The number in the upper outer corner is for page sequence within the issue only. The number in the lower outer corner, which is followed by the letter "a," denoting "abstracts," is for the convenience of those who bind Corrosion Abstracts by volumes. Because both numbers appear on each page and because it is believed indexing by the volume serial number will be more useful, the "Index to Corrosion Abstracts" is keyed to the number in the lower outer corner of each page followed by the letter "a."

CORROSION TYPES & INFLUENCING FACTORS

• Types

3.2, 2.3, 3.5, 4.3

Caustic Cracking at Elevated Temperatures. C. D. Weir. Paper before IME, Great Britain. *Combustion*, 21, No. 8, 73 (1950) Feb.

The results of tests conducted at the University of Glasgow on the caustic cracking of steel in the presence of sodium hydroxide solutions at high tempera-

tures are described. The hollow specimens showed that it was possible to produce failure of notched specimens rapidly and consistently, but homogeneously stressed specimens appeared to be immune. All fractures were intercrystalline. Dilute caustic solutions were found to be very much less effective than those of high concentration. Pure NaOH was extremely effective in producing failure, and the addition of silica did not materially influence the results. Neither the addition of tannin, nor the use of fine-grain steels were entirely effective in preventing intercrystalline failure, although in the case of the latter increased resistance was noted, particularly when slightly higher in C content. Cathodic polarization was found to be protective, while anodic polarization did not prevent, and possibly hastened, failure.—INCO.

3.2

Causes of Blistering of Electrodeposits on Zinc Alloy Die-Castings. S. Wernick, H. H. Symonds and H. C. Castell. *J. Electrodepositors' Tech. Soc.*, 24, 195-210; discussion, 217-220 (1949).

Blistering formed on plated zinc-base die-castings are divided into two categories, designated service blisters and process blisters. The former are normally encountered on castings which have been in service for some time, and at the site of such blisters there is a pore or fissure in the deposit. Atmospheric corrosion after plating plays an important part in forming these blisters, and the condition of the deposit itself appears to be the primary factor in affecting the tendency to blister. Process blisters are normally encountered immediately after the plating operation, under circumstances where over-cleaning, brittle copper diffusion layers, grease, etc.,

do not necessarily provide an explanation. They are characterized by considerable internal pressure and, unlike service blisters, there is no pore or fissure in the deposit above them. Atmospheric exposure plays no part in their formation, but the condition of the surface before plating, i.e. whether polished or unpolished, has a bearing on the tendency to blister. The main causes of the former type of blister are porosity due to such causes as inadequate thickness, pitting, etc., the inclusion of local foreign matter and stress in the deposit. The main causes of process blisters are related to the production of locally corroded areas on the casting surface which adversely affect the deposition of sound plate. The surface corrosion of the casting is intergranular in nature, and this provides conditions for the trapping of electrolyte which in turn may react with the zinc and produce blisters. Process blisters are most effectively prevented by avoiding storage under corrosive conditions and protecting the casting during the period it is left in the as-cast or polished condition, before plating. 16 references are given.—MA.

• Factors Biological

3.3, 4.6

Symposium on Marine Fouling. Symposium before ASME, Spring Mtg., New London, Conn., May 2-4, 1949, and Semi-Ann. Mtg., San Francisco, June 27-30, 1949. *Trans. ASME*, 72, No. 2, 101-131; Disc. 133-144 (1950) Feb. Papers include:

Some Biological Fundamentals of Marine Fouling, by W. F. Clapp.
Project Study for the Mitigation of

PRIMARY SOURCES OF ABSTRACTS PUBLISHED IN CORROSION

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario, Canada.

AWWA—Journal, American Water Works Association. Amer. Water Works Assoc., 500 5th Ave., New York 18, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BLR—Battelle Library Review, Battelle Memorial Institute Library, 505 King Ave., Columbus, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California, 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W#1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

ME—Marine Engineering, The Institute of Marine Engineers, 85/88 The Minories, London E. C. 3, England.

MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards, Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

PDA—Prevention Deterioration Abstracts, National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers, 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France, 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.

TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association, Lincoln House, Turl Street, Oxford, England.

Marine Fouling, by I. A. Patten, Lynn Gas & Elec. Co.

Control of Marine Fouling in Sea Water Conduits Including Exploratory Tests on Killing Shelled Mussels, by H. E. White, Stone & Webster Eng. Corp.

Thermal Control of Marine Fouling at Redondo Steam Station of the Southern California Edison Company, by W. L. Chadwick, So. Calif. Ed. Co.; F. S. Clark, Stone & Webster Eng. Corp.; and D. L. Fox, Scripps Inst. of Oceanography of Univ. of Calif.

In his paper on the common mussel, Dr. Clapp includes chlorination tests on mussels at Kure Beach and quotes results. Patten's paper is a resume of experiments and the development of a CI program which is effective and economical.—INCO.

3.3, 6.6

Wood Preservatives and Mildewicides. *Can. Paint & Var. Mag.*, 23, No. 8, 46-7 (1949).

Chemical preservatives against rot-producing fungi and mildew have been developed during the war. The cell walls of the wood fibres are destroyed by the enzymes secreted by the micro-organisms. Spores are spread to the wood by wind, water or even insects and propagate through the wood, particularly when wet. Spraying, dipping or brushing with solutions of Cu, Zn or Hg naphthenate kills these micro-organisms and prevents them from spreading. Chlorinated phenols and organic Hg compounds are also used. Sealers containing good preservatives should prevent attack by powder post beetles and termites, preserving the wood from

moisture and decay and serve as a primer for further painting.—RPI.

3.3, 6.6

Decay of Timber by Fungi. W. P. K. Findlay. *Endeavour*, 8, No. 31, 112-9 (1949).

The role of fungi in causing the decay of timber has been recognized for about a century, and much work has been done on elaboration of methods of preservation during that time. The preservatives more commonly used are creosote, pentachlorophenol and Cu naphthenate. The latter two are oil-soluble and are not leached out by rain, and wood treated with them can subsequently be painted.—RPI.

3.3, 5.4

Deterioration of Paint Films Caused by Moulds. H. Rabate. *Peint. Pig. Vernis*, 25, No. 4, 129-30 (1949).

A general article on the problem of microbiological attack.—RPI.

3.3, 6.6

Deterioration of Wood by Insects. W. D. Reed and T. E. Snyder. Office of Naval Research, Wood Symposium, 1949, 14 pp. *Prev. Det. Abs.*, 7, W 28 (1949).

The habits of wood-boring beetles, termites and marine borers are outlined. Suggestions are made for the treatment of woods to immunize them against attack by these pests.—RPI.

3.3, 6.6

Recent Developments in Improving the Marine Borer Resistance of Lumber and Plywood Used in Planking Naval Vessels. T. L. Shoemaker. Office of Naval Research, Wood Symposium, 1949, 21 pp. *Prev. Det. Abs.*, 7, W 9 (1949).

The duration of protection against marine borers over a period of 30 months is reported. Creosote A when applied to pine panels by the hot-and-cold-bath method prevented serious attack up to a period of 26 months. Treatment with Cu chromate/arsenate gave good protection to wood (including plywood) and so did anti-fouling paints containing a high proportion of Cu_2O .—RPI.

3.3, 5.4

New Anti-Fouling Method. Syren & Shipp, 212, 375 (1949). *J. Brit. Shipbuilding Res. Assoc.*, 4, No. 10, 3041 (1949).

A new anti-fouling preparation applied by a pneumatic gun at 212° F has been evolved in Sweden and is now undergoing trials in tropical waters.—RPI.

3.3, 2.3

Determination of Fungicides in Varnishes and Wood Sealers. M. H. Swann. *Anal. Chem.*, 21, No. 7, 804-6 (1949).

Salicylanilide and pentachlorophenol are extracted by alkali from solns. of the vshs. Acid ppts, the two compounds are then extracted with ether and the process repeated. Aliquot samples of the soln. are taken for the spectrophotometer detns. Salicylanilide is detd. with ferric salts and pentachlorophenol by its own color in benzen soln. Hg compounds if present can be detd. on a further sample of material by an improved method.—RPI.

3.3

Corrosion and Fouling. (In Russian.) N. I. Tarasov. *Priroda (Nature)*, 38, 32-38 (1949) Nov.

On the basis of experimental investi-

ACIPCO PIPE

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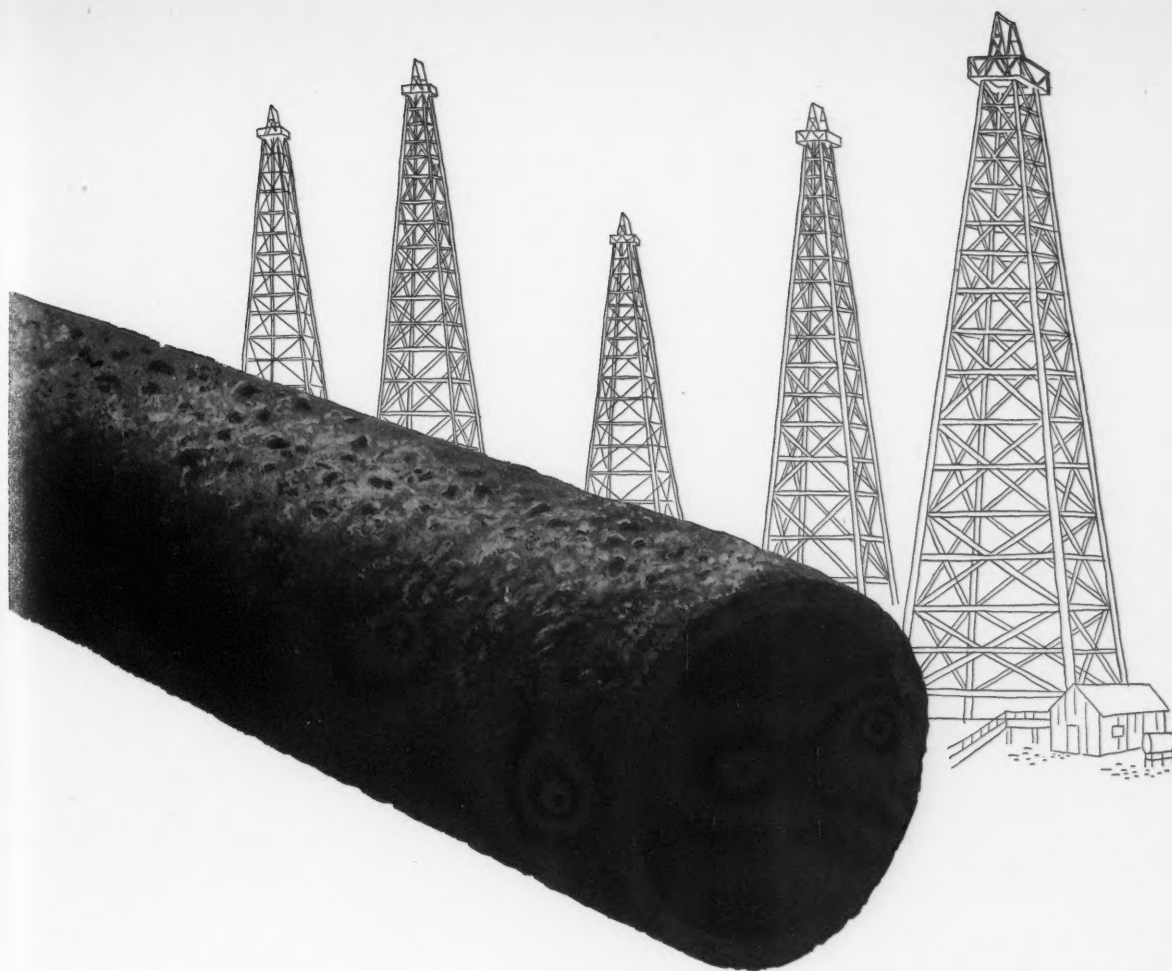
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gation and literature data, the above problem is briefly reviewed, particularly for ships and hydroelectric plants. Factors involved are discussed and methods of prevention are critically analyzed. 26 ref.—BLR.

CORROSIVE ENVIRONMENTS

• Atmosphere

4.2, 2.2, 6.2

A Study of the Corrosion Resistance of High-Alloy Steels to an Industrial Atmosphere. H. T. Shirley and J. E. Truman. Paper before Iron and Steel Inst. and Brit. Iron & Steel Research Assn., London, Oct. 18, 1949. *Metalurgia*, 41, No. 241, 8-9 (1949) Nov.

In paper concerned with the question

of industrial atmosphere and its effect on high alloy steels, a description is given of tests designed to study the effects of composition and surface finish on the behavior of higher alloy steels, when exposed for prolonged periods to severely industrial atmospheric conditions, without attention to the cleansing treatment normally recommended for such materials. 18 Cr-8 Ni-2.5 Mo and 24 Cr-12 Ni-3 W steels were outstandingly good in behavior. In general the more resistant steels tended to show higher losses in the case of emiered surfaces, than for pickled and mirror-polished finishes.—INCO.

4.2, 6.2, 6.3

Tests on the Resistance of Refractory Alloys to Corrosion by Combustion

Gases. (In French.) *Rev. Met.*, 46, No. 12, 843-848 (1949) Dec.

Describes apparatus and method used in tests on Ni- and Fe-base alloys in air, and in gas containing 8%CO₂, 8%H₂O, 5%O₂ and 79N₂ with and without 1% SO₂ at 800, 900 and 1000° C.—BNF.

4.2, 6.3, 6.4

Controlled Atmospheres for Metals, Part IV—Atmospheres for Nonferrous Metals. L. F. Spencer. *Mats. and Meths.*, 30, No. 4, 91-92 (1949) Oct.

The atmospheric constituents harmful to copper-base alloys, aluminum and its alloys, and magnesium during heat treatment are discussed, and suggested protective measures are outlined.—ALL.

4.2, 5.10, 6.5

Design of Exhaust Systems Handling Corrosion Fumes and Gases. F. H. Stebbins. *Sheet Metal Worker*, 39, No. 5, 55-56, 105 (1948) May.

Discussion of the materials to use, the cleaning process and a specific problem overcome by design. A table on the different materials usually used in building exhaust systems is given and includes Monel, 18-8 and Al.—INCO.

PREVENTIVE MEASURES

• Metallic Coatings

5.3

Metallizing for Corrosive Protection. J. E. Wakefield. *Iron Age*, 165, No. 2, 55.60 (1950) Jan. 12.

Characteristics of Zn and Al coatings and their applications. Mentions technique of spraying on an 0.0015-0.002 in. steel flash undercoat to give better bonding, also touches on new technique of applying composite layers (of Metco-Weld H with 18/8 stainless steel, Monel or Ni) which can be fused after spraying to give a non-porous coating.—BNF.

5.3

New Metallizing Techniques Offer Production Economies and Simplified Design. John E. Wakefield. *Iron Age*, 164, No. 10, 80-84 (1949).

W. discusses the latest developments in metallizing that give more uniform coatings and higher application speeds, and describes the practical uses of metallizing, including parts for heat- and corrosion-resistance. In a method using a self-bonding undercoat (not further specified), all but the first steps are eliminated.—MA.

5.3

Preparing Shafts for Metallizing. John E. Wakefield. *Machinery (American)*, 56, 174-177 (1950) Feb.

Correct preparation of base metal is the most important factor in successful spraying of metal. First, the surface must be cleaned thoroughly and second, it must be roughened in such a way that there will be hooks and craters for the molten particles of sprayed metal to key into. Describes and discusses six methods of roughening shafts prior to metallizing.—BLR.

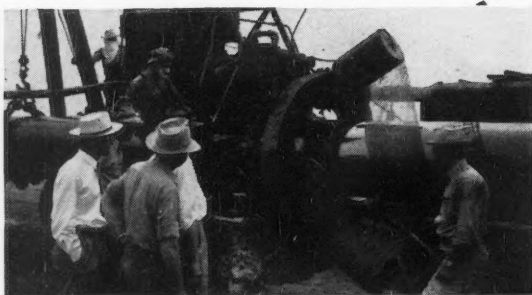
5.3

Metal Coatings Improve Solder Flow on Steel and Brass. David Wallace, Sperry Gyroscope Co., Inc., Great Neck, N. Y. *Mat. & Meths.*, 29, No. 5, 60-63 (1949) May.

Rosin flux, desirable for its noncon-

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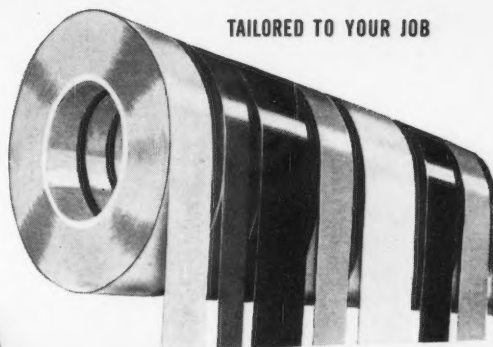


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Meter readings showed Polyken No. 882 had an electrical resistance averaging one megohm per square foot of covered surface.

After two years of being subjected to these test conditions the pipe was removed, as illustrated above.

The Research Department found Polyken No. 882 as alive and serviceable as the day it was buried. Polyken No. 882 still had an electrical resistance that

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Further, although under the most severe type of soil stress there was no cracking, wrinkling or peeling of Polyken Tape No. 882.

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Polyken Industrial Tape, Department of Bauer & Black, Division of The Kendall Company

ducting and non-corrosive properties, does not provide good solder flow on tin plated parts which have been in storage for 3 mo. to 1 year. This is attributed to the difficulty the flux experiences in dissolving surface oxide. Solderability is preserved when parts are given a solder coating of a lead-tin alloy by hot dipping or, when coating thickness is important, by electroplating.

Hot dipped 60-40 lead-tin solder coatings, melting at about the same temperature as the joining solder and capable of breaking up interfering oxide films, have good solderability after 1-yr storage but their thickness, 0.0003 in.-0.010 in., is objectionable on parts used as inserts in molds for plastic injection. Coatings were applied by dipping the parts in a water solution of a zinc chloride type flux and then in a molten solder bath, spinning them in a centrifuge to remove excess solder, and then quenching in a clean cold water to remove flux residues. These rapidly cooled finishes retained a bright surface free of oxide films.

Best over-all results were obtained with an electroplated lead-tin alloy. The coatings have uniform thickness and maintain excellent solderability for at least a 9-mo. period. The bath, developed by the General Chemical Co., produces coatings about 0.0002 in. thick with approximately the eutectic composition of lead and tin.

The ability of a coating to promote soldering was judged by the extent to which the solder spread on a heated panel. For this test 1-in. lengths of rosin core 60-40 solder were melted on coated panels kept at 420 F by an electrically heated hot plate. Panels were left on the hot plate for 15 sec. after the solder melted.—PDA.

● Surface Treatment

5.9, 5.3

Recommended (ASTM) Practice for Preparation of Low-Carbon Steel for Electroplating (B183-49). ASTM Specifications and Tests for Electrodeposited Metallic Coatings, 44-47, 1949.—MA.

5.9, 6.4

Report of Test of "Alodizing" Process for Anodic Treatment of Aluminum Alloys. (Submitted by American Chemical Paint Company, Ambler, Pa. Test C-3201). U. S. Naval Engineering Experiment Station, Annapolis, Md. (1948) Mar.

Various surface treatments for aluminum alloys, including two proprietary Alodizing processes and two anodizing treatments in sulfuric and chromic acid, were tested for ability to resist corrosion and abrasion. On unpainted specimens, the chromic and sulfuric acid film treatments were superior to either of the Alodizing treatments in over-all resistance. Alodine No. 1, in the few tests made on unpainted surfaces, was superior in corrosion resistance to Alodine No. 2. Painting should accompany the use of the latter, since alloys treated with Alodine No. 2 and exposed in an unpainted condition were sometimes inferior even to the corresponding untreated alloys, e.g., 24S-alloy. When differently treated, but similarly painted specimens were compared, Alodine No. 2 provided a paint base as good as or

better than the chromic or sulfuric acid treatment.

The specimens investigated included 3S, 24S, 52S, and 61S aluminum alloys. One half of each lot of surface treated panels was sprayed with one coat of zinc chromate primer and one coat of haze gray paint. Total paint thickness was 0.003 in. Painted and unpainted surface treated specimens were subjected to the following tests: spraying at 90 ± 5 F with 20% sodium chloride mist; exposure to 100% RH at 100 F in a humidity cabinet while rotating at 3 rpm; exposure in a Weatherometer unit embodying controlled ultraviolet irradiation; immersing in river water for 20 min., followed by exposure to air for 20 min.; continuous immersion in river water; and two types of abrasion tests including one with a Taber Abraser. In addition, natural weathering tests in a marine atmosphere were initiated.—PDA.

5.9, 6.4

The Anodic Treatment of Aluminum and Its Alloys for Use in the Mouth. F. Granville and T. Tregarthen. *British Dental J.* (England), 86, 227-228 (1949). *Chem. Abst.*, 43, 8284 (1949) Nov. 10.

An electrolytic process is described for the conversion of the surface layer into alumina producing an adherent corrosion resisting coating.

5.9, 5.4

The Effect of Surface Treatment of Brass and Yellow Metals on Adhesion of Paint Films with Special Reference to the Painting of Optical Equipment. Selected (Brit.) Gov't Research Rep., Vol. II. *Paints, Rep.*, 1949, No. 4, 29-34.

Two paints were spray-applied and one brush-applied to 70 : 30 brass sheet, copper foil, and copper strip and the panels stored for 1 hr. at 280° F (138° C). Comparison was made between surfaces which had been a) highly polished, b) burnished with No. 0 emery cloth, and c) etched as follows: immersion at room temp. in a solution containing sodium dichromate crystals 200 g, conc. sulphuric acid 40, and water 1000cc. The time of immersion should be the minimum required to produce a clean surface and not longer than 1 or 2 min. Bend and scratch tests were made before and after accelerated ageing. Impact tests were also made after accelerated ageing. Full details are presented of the test methods used. The accelerated ageing was carried out using a Weatherometer (refrigeration cycle of B.S. 987 : 1942). It is concluded that the etching treatment improves the adhesion of the paints tested on both brass and copper, the improvement being particularly marked in the case of scratch- or abrasion-resistance of the film.—MA.

5.9

Chemical Scale Removal. C. H. Carter, Puget Sound Pulp & Timber Co. *Power*, 94, No. 3, 88-90 (1950) Mar.

Discussion includes scale formation, acid cleaning, feeding the acid, neutralizing acid and boiler results. The procedure using a commercial inhibited muriatic acid to clean the stainless steel pumps is given. When finished, an inspection of boiler parts revealed that all scale was gone and the metal bright and clean.—INCO.

5.9, 6.4

Surface Preparation : New Studies on the Oxidation of Pure Aluminum. G.

Chaudron and P. J. G. Lacombe. *Metal Ind.* (England), 76, No. 4, 69-70 (1950) 27 Jan.

Aluminum surfaces polished mechanically by means of abrasives suffer important structural modification of the uppermost layer. Electrolytic polishing, however, enables a surface to be produced which is completely free from any structural disturbance although the authors have been able to show that electrolytic polishing often seems to involve the formation of a chemically changed skin. The state of oxidation of aluminum was recorded by measuring the solution potential. Polishing baths for aluminum can give polished surfaces practically free from oxides; or can produce a metallic surface covered with a more or less thick layer of alumina. When aluminum is electro-polished in the bath due to Jacquet (a mixture of anhydric acetic acid and perchloric acid) the solution potentials given by the surface in a 3 percent NaCl solution against a calomel electrode saturated in KCl is -1.20 v., which anodic value corresponds to a surface almost free from oxide (after washing and drying with absolute alcohol) and it is characterized by many novel chemical and physico-chemical properties. Mechanically polished aluminum gives a solution potential of -0.74 v., which corresponds to a surface which has undergone oxidation in contact with water in the course of abrasion. If it is assumed that the value of the solution potential varies linearly as a function of the thickness of the oxide layer, it may be deduced that the rate of oxidation is a logarithmic function of time. The composition of the electrolytic polishing bath is a controlling factor in the nature of the surface produced. Baths of mixtures of phosphoric and sulfuric acids or of nitric acid and methyl alcohol always give transparent oxide layers, whatever the polishing conditions. In the authors' experience, the whole series of successive operations of electrolytic polishing, washing the specimens and potential measurement must be carried out in a rigorously airtight apparatus in which purified nitrogen is circulated. The best washing liquid was de-aerated and anhydrous, butyl alcohol.—ALL.

5.9

Amorphous Phosphate Coatings for Protection of Aluminum Alloys and for Paint Adhesion. A. Douy and F. P. Spruance, Jr. *Proc. 36th Ann. Conv., Amer. Electroplaters' Soc.*, 193-216, 1949.

Discussion of process and characteristics of amorphous phosphate coating for Al, known as Alodine; includes comparisons with various other coatings.—BNF.

5.9

Polishing and Cleaning Metals Prior to Finishing. E. Engel. *Tool Eng.*, 24, No. 3, 43-47 (1950) Mar.

The electropolishing and cleaning of metals as brass, Monel, Ni, Ag, stainless steel, and Zn are discussed. Monel and Ni can be processed in a 63 H₃ PO₄—15 H₂ SO₄—22 H₂ O solution at high current density. Stainless steel electrolytes are sulfuric-phosphoric-chromic or citric-sulfuric acid solutions. Monel and Ni are cleaned in a solution of 1/2-1 lb. or NaCN. Cathodic cleaning of buffed Ni plate is done in strong sulfuric or hydrochloric acid solutions. Stainless steel is descaled and then cleaned in a fused Na bath. The preparation of steel for lacquering and for plating, and the testing of cleaning solutions are described.—INCO.

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5.9
Amorphous Phosphate Coating for Aluminum Alloys. Allen G. Gray. *Prod. Fin.*, 14, 60, + (1950) Jan.

Reviews paper by Alfred Douty and F. P. Spruance, Jr., presented at 1949 AES Convention. Describes "Alodine" coating which resists corrosion and also serves as a base for organic coatings. Test panels are illustrated.—BLR.

5.9
Corrosion Resistance Treatment for Zinc Die Castings. *Iron Age*, 165, 83 (1950) Feb. 9.

Outlines proprietary chemical treatment used by Easy Washing Machine Corp., Syracuse, N. Y., which not only increases resistance to surface corrosion, but also serves as a good preparation for enameling.—BLR.

5.9, 6.4

Influence of Surface Contamination on the Corrosion of Magnesium-Manganese Sheet (Influence de la contamination superficielle sur la corrosion des toles en alliage de magnesium et de manganese). L. Rakowski. *Metaux et Corrosion* (France), 24, No. 289, 193-210 (1949) Sept.

It has been observed that on a certain number of magnesium-manganese alloy sheets of the composition according to British Specification D. T. D. 118, it is difficult to obtain a uniform chromate film in the heat treatment bath following the normal alkaline cleaning treatment. These sheets had been previously treated in the acid chromating bath and lanolated by the fabricator, the lanoline having been removed by an organic solvent before the application of the alkaline cleaning treatment. It is also noted that after

the chromating treatment and R. A. E. test under intermittent sprinkling with sea water, these sheets tend to corrode in an un-uniform manner; corrosion attacks in a certain number of isolated points, which are noticeable from the first moments of the test. In some places, the sheet is eaten through, while others remain completely unaffected. As shown by the illustrations in this article, corrosion takes the form of small annular pits around the unattacked zones, quite irregular. It is believed that this phenomena is caused by superficial contamination of the sheets. Various tests show that it is possible to control this corrosion by applying different cleaning and acidic scouring treatments before chromating.—ALL.

5.9

The Application of Wear Resistant Phosphate Coating to Ferrous Surfaces. M. B. Roosa, Parker Rust Proof Co. *Amer. Soc. Lub. Engrs.* (Preprint of paper to be presented at the 1950 Annual Convention of ASLE).

The application of phosphate coatings to ferrous surfaces, combined with well-engineered lubrication, is accepted today as a proven method for reducing wear and galling on mating parts. The wear-resistant phosphate coating is produced by chemical immersion of the properly cleaned parts in a bath of metal acid phosphates containing free phosphoric acid and accelerating media. The type of coating and degree of etch depend in large part on the cleaning method used prior to treatment. The nonmetallic and oil adsorptive characteristics of the crystalline coating prove highly beneficial on bearing surfaces through the prevention of "welding," increase in lubrication efficiency, and assurance of rapid and safe breaking. The automotive, aircraft, and Diesel-engine field offer many practical applications for phosphate coatings where wear is a problem. The over-all saving to be effected by changes in manufacturing procedure and elimination of field failures is a point of principal interest to manufacturers. This treatment provides the mechanical, automotive, and lubrication engineer an economical means for assuring a product of maximum quality and life service.—TDD.

5.9

Blast Cleaning with Suspended-Abrasive Media. Edward Rosen. *Met. Fin.*, 47, No. 10, 76-78, 80 (1949).

The method consists of the use of a circulating abrasive suspended in an aqueous solution, which is directed against the work under pressure through a nozzle. By controlling type of abrasive and mesh size, ratio of abrasive to solution, air pressure, angle of impingement, and distance of gun from the work, it is possible to obtain a wide range of finishes. Many types of abrasive have been used, including sand, Novicite, a siliceous rock, cereals, rice husks, and ground peach stones. The method has been used for deburring, paint removal, and several other jobs, particularly for the preparation of metals for plating.—MA.

5.9

The Development and Application of the Atrament Process Under Present Economic Conditions. F. Rosseuscher. *Arch. Metallkunde*, 3, No. 2, 66-71 (1949).

Bath compositions and operating conditions for the various modifications of the Atrament process, which is a long-immersion process producing films of manganese phosphate on iron and zinc,

are described. The applications of the method in regard to quality and corrosion-resistance of the finished products are discussed.—MA.

5.9

Solvent Degreasing: A Production Tool. A. E. Rylander. *Tool Eng.*, 22, No. 1, 21-23 (1949).

For cleaning and preparation before rust-proofing, anodizing, &c., solvent degreasing warrants consideration. The process is carried out by vapor, immersion or spray methods. The use of each method in the production line is discussed with illustrations.—MA.

5.9

The Chromizing Process. H. Sanders. *Pract. Eng.*, 17, No. 425, 256-257 (1948).

A description is given of various processes by which a chromium-rich layer may be deposited on surfaces of materials, mainly steel.—MA.

5.9

Pickling, Etching, Pre-Treatment, De-rusting, and Protective Treatments (for Metals).—V. Richard Springer. *Metalloberflache*, 3, Nos. 2, 4, 45-50; 96-99 (1949). *Cf. Met. Abs.*, 16, 841 (1949).

S. deals with: a) chemical, thermal, and mechanical methods of derusting and descaling; b) corrosion protection by phosphatizing, by treatment in solutions containing oils, fats, and soaps, in solutions of organic mercaptans, sulfides, and azides, and by passivation; c) pickling brittleness, due to the solubility and adsorption of nascent hydrogen, in steels; d) theories as to the reactions which may and can occur in the pickling of iron; e) diverse pre- and post-pickling treatments; f) patents relating to the pickling of many metals; g) the sharpening of files by acid pickling; and h) practical hints.—MA.

5.9

The Acid Bath Examined. J. F. Stirling. *Pract. Eng.*, 18, No. 459, 499-501 (1948).

A description is given of the oxide film present on metals, and of various pickling baths and treatments used to remove scale, &c.—MA.

5.9, 6.4

Study of Layers of Alumina Deposited on Aluminum by Anodic Oxidation. (In French.) J. J. Trillat and R. Tertian. *Revue de l'Aluminium*, 26, 315-319 (1949) Oct.

Four samples of high-purity (99.99%) Al were anodized in a sulfuric acid bath. Two of the samples were sealed to prevent further oxidation and two were not. The character of the oxide films was studied by X-ray and electron diffraction. No difference between sealed and unsealed films was detected. Progressive pickling of thick films seem to indicate that the superficial texture of the oxide does not extend to the deeper layers which are amorphous in character.—BLR.

5.9, 6.4, 5.4

Surface Treatment and Finishing of Light Metals—Part V. S. Wernick and R. Pinner. *Sheet Metal Ind.* (England), 27, No. 273, 71-81 (1950) Jan.

Methods of protecting aluminum and its alloys from corrosion by chemical conversion coatings of two types based on 1) the thickening of the natural oxide present on aluminum surfaces and 2) the production of phosphates (aluminum or zinc

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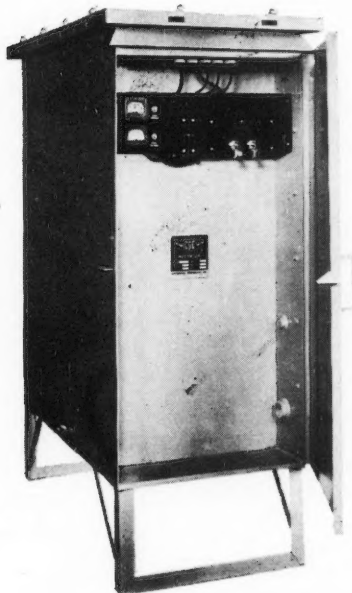
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phosphates), are described. The function of conversion coatings is to act as an undercoating and a base for organic finishes. The natural oxide film on aluminum has a variable thickness depending on alloy composition and time of exposure, but is normally in the range of 0.0000002 to 0.0000006 in. By suitable chemical treatment, oxide coatings are obtainable which are 100 to 200 times as thick, and are more porous and absorptive, forming a good base for organic finishes. The history and theory of chemical oxidation are described, with detailed descriptions of the M. B. V. process (chemical employed, equipment, pretreatment, effect of alloy composition, operating conditions and film growth, process control, sealing and dyeing of M. B. V. coatings). Experiments carried out on M. B. V. and E. W. coatings on aluminum and aluminum alloy castings showed that when applied to untreated castings, adequate corrosion resistance was obtained, although the presence of the casting skin had a marked effect on the appearance and color of the film. Results obtained with various alloys are tabulated. The influence of mechanical finish results shows that the appearance of aluminum castings on M. B. V. treatment is largely dependent on the polish obtained. The effect of alloy composition on the color of dye and the properties of dyed M. B. V. coatings on aluminum are also tabulated. The E. W. process was developed to produce colorless coatings, and is described with regard to bath composition, operating conditions, and fluoride-containing solutions. A comparison is given of the two processes, which are complementary rather than competitive and are employed for different purposes.—ALL.

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5.9, 5.4

Preparation of Aluminum Sheet Surfaces for Painting. R. I. Wray. *Am. Paint J.*, **33**, No. 52, 28-9, +; also in *Am. Paint & Oil Dealer*, **42**, No. 2, 34-35 (1949).

On exterior surfaces weathering is usually sufficient to prepare the surface for painting. Under exceptional conditions, degreasing, abrading, or a H_2PO_4 treatment may be necessary. A primer, which is Pb-free or contains <15% Pb, should be used. Gutterings need a bituminous paint. Interior surfaces should be degreased and abraded. An alkyd enamel is satisfactory. In industrial buildings an anti-corrosive primer containing 10-20% Zn chrome may be used. Where Al is joined to another metal, a Zn chrome primer should be used. Where it is joined to wood, the wood should receive 2 coats of an Al primer.—RPI.

5.9

Phosphatization as a Topochemical Reaction. A. Wustefeld. *Arch. Metallkunde*, **3**, No. 1, 43-45 (1949).

Experiments, which are described, show that the formation extent, type, and grain-size of phosphate coatings are dependent on the surface condition of the metal being treated. Pretreatment of the metal surfaces by polishing with coarse or 4/0 emery produces coatings having fine-grained structures which are a little harder than the original metal surface; pickling before phosphating produces hard coatings which contain large, bright, needle-like structures set in a fine ground-mass; washing with nitrite solutions after pickling gives fine-grained softer coatings. Unlacquered coatings show adsorption when immersed in soap solutions, such adsorption taking place in the ground-mass and in the needle-like structures when acid and alkaline solutions of the soap are used, respectively. The adsorbed films are often so thick that it is probable that polymerization also takes place; they are not easily removed by degreasing agents. It follows, therefore, that phosphatization must be a topochemical reaction, topochemical reactions being those in which the properties of the solid reaction product formed on the surface of the material are determined, to a great extent, by the nature of the surface.—MA.

5.9

Influence of Size and Shape of Parts or Test Specimens on Depth and Composition of Layers Resulting from Thermochemical Treatment of Steel. (In Russian.) M. M. Zamyatin. *Doklady Akademii Nauk SSSR* (Reports of the Academy of Sciences of the USSR), new ser., **68**, 725-728 (1949) Oct. 1.

Apparently refers to such processes as cromizing or nitriding. Presents theoretical analysis of the effects of above factors, also of time, temperature, and composition. Results are shown graphically.—BLR.

5.9

Aluminum—Its Surface Preparation and Finishing, Part II—Electroplating on Aluminum. E. R. Yarham. *Prod. Fin.* (U. S. A.), **14**, No. 2, 40-42, + (1949) Nov.

This article deals chiefly with 1) the existence of the oxide coating on aluminum; 2) the rapidity with which that coating reforms on the surface that is being treated; and 3) the solvent effect of the electrolyte. A table showing the plating processes for aluminum, and a flow sheet for zinc-immersion process on alu-

minum with indications of end uses for the plated product are included. In conclusion reference is made to suitable racks for plating aluminum.—ALL.

• Miscellaneous Methods

5.10

Proper Bonding of Power Cable Sheath Guards Against Galvanic Corrosion. W. D. Sanderson. *Corrosion*, **5**, No. 11, 403 (1949) Nov.

Fastening groups of Pb cable sheaths together with Cu wires at manholes, in order to prevent potential differences among cable sheaths in the same circuit and to provide a path for the return current in case of failure, has been found to cause contact corrosion of the sheaths unless precautions described are taken.—BNF.

MATERIALS OF CONSTRUCTION

• Ferrous Metals & Alloys

Developments in Alloy Steels. T. H. Arnold & V. C. Mills. *Metallurgia*, **41**, No. 242, 75-78 (1949) Dec.

Review focuses attention on some development aspects concerned with steels for high-temperature service, resistance to corrosion, and to wear. Specimens were exposed to the estuarine water at Whitmans Bay, Freetown, Sierra Leone. Photographs show appearance of the specimens after they were cleaned free from marine growths and corrosion products. Specimens included mild, 13 Cr, 18 Cr-2 Ni, 18 Cr-8 Ni, 10 Cr-20 Ni W-2 Cu, and 36 Ni steels.—INCO.

6.2

Acid-Resisting High Silicon Iron Castings. British Standards Institution. British Standard 1591, 7 pp, 1949. Obtainable from B. S. I., 24/28, Victoria Street, London, S. W. 1. 2s.

Chemical composition; heat treatment; moulding; freedom from defects; provision of sample for and method of chemical analysis; porosity; repairs to castings; welding; marking and packing; inspection; testing facilities; test certificates.—BNF.

6.2

Corrosion-Resistant Steel Alloys. *Elec. Mfg.*, **45**, No. 3, 146, 148 (1950) Mar.

SR steels have as good chemical and corrosion resistant properties as stainless steel and high Ni-Mo alloys. All grades can be melted in the usual electric arc and induction furnaces, are not sensitive to their C content, are castable and machineable. Their electrical conductivity is 15% higher than 18-8 stainless steel. Mfg. by Uniworld Research Corp. of America.—INCO.

6.2

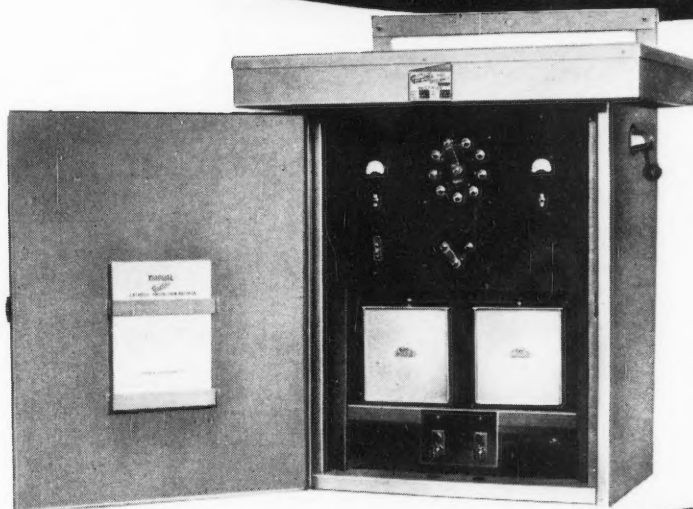
Corrosion: Corrosion-Resistant Alloys Reviewed. M. G. Fontana. *Ind. Eng. Chem.*, **41**, No. 12, 79A-80A (1949) Dec.

Briefly reviews use of ELC (extra-low C) stainless steel, Chlorimet, Carpenter 20 (wrought form of Durimet 20), and various alloy steels. A warning is given

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6.2, 2.3, 4.2, 3.5

Corrosion and Corrosion Fatigue of Steel. Papers before Joint Meeting of Iron & Steel Inst. & B. I. S. R. A., Oct. 18. *Iron & Coal Tr. Rev.*, 159, 1115-1118 (1949) Nov. 11.

Simple Form of Accelerated Atmospheric Corrosion Test by R. St. J. Preston.

Study of Corrosion Resistance of High-Alloy Steels to an Industrial Atmosphere by H. T. Shirley & J. E. Truman (good behavior of 18-8 2% Cr-Ni-Mo and 24-12-3 Cr-Ni-W steels).

Atmospheric Corrosion of Iron and Steel Wires by J. C. Hudson.

Climatic Effects on the Corrosion of Steel by J. Dearden.

Effect of Shot-peening on the Corrosion Fatigue of a High-Carbon Steel by U. R. Evans.

Corrosion Fatigue of Steel Under Asymmetric Stress in Seawater by A. J. Gould.

6.2

Austenitic and Special Stainless Steels. Samuel J. Rosenberg. *Prod. Eng.*, 21, 113-117 (1950) Jan.

Second of two articles giving a basic review of the corrosion-resistant or stainless steels. Gives properties, heat treatments, and fabricating characteristics of the austenitic and special steels. Includes tables, graphs, micrographs, and illustrations of applications.—BLR.

6.2, 3.2

Low Carbon. No Stabilizer Makes a New Stainless Steel Resist Industrial Corrosion. P. F. Voight, Jr., US Steel Corp. *Blast Furnace & Steel Plant*, 37, No. 12, 1479 (1949) Dec.

Instead of adding Cb or Ti to austenitic 18-8 stainless steels as stabilizers to minimize the adverse effects of C and thereby render the alloy less susceptible to intergranular corrosion, the C content was reduced. Tests indicated that the low C 18-8 steels have a resistance to intergranular corrosion equivalent to that of stainless steels to which Cb and Ti were added.—INCO.

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Corrosion Problems Related to Air Transport Aircraft, by Otto E. Kirchner and Fred M. Morris, American Airlines. A paper prepared for presentation at NACE meeting, St. Louis, Mo., April, 1950.

The Influence of Stress on Corrosion, by Julius J. Harwood, Office of Naval Research, Washington, D. C. Reprinted from *CORROSION*, Vol. 6, No. 8 and 9 (1950). A paper presented at the NACE meeting, St. Louis, Mo., April, 1950.

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● Non-Ferrous Metals & Alloys—Heavy

6.3

Phosnic Bronze—A New Copper-Base Alloy. D. K. Crampton, Chase Brass & Copper Co. *Wire & Wire Prod.*, 25, No. 3, 228-230, + (1950) Mar.

Phosnic bronze, 1.10 Ni-0.22 P-98.6 Cu, is a new alloy with high strength, high fatigue strength, hardness, and high electric conductivity. It has greater creep strength at 80° and 300-500° F than other annealed bronzes and also greater elastic modulus. This alloy has high corrosion resistance and is capable of varying degrees of cold working and is readily hot worked. It can be used for springs, clips, electrical conductors, bolts, and screws. Tables of the physical mechanical, thermal and electrical properties are given.—INCO.

6.3, 6.4

Corrosion. M. G. Fontana. *Ind. & Eng. Chem.*, 42, No. 3, 83A-84A (1950) Mar.

Articles on new developments in metals and alloys describes corrosion applications for Al and Cu and their alloys. 0.75 Sn-0.25 Si-0.15 Mn, balance Cu alloy welding rod No. 372 made from Am. Brass Co. is used for welding Cu by the oxyacetylene and inert gas shielded-arc method. Alloy No. 1014 containing 7 Al-2 Si-91 Cu has good corrosion resistance, free cutting qualities, high annealed strength, and good forgeability.—INCO.

6.3

Titanium Symposium. Symposium before ACS, 116th Mtg., Div. Ind. & Eng., Atlantic City. *Ind. & Eng. Chem.*, 42, No. 2, 214-268 (1950) Feb.

Papers included are:

Potential Uses of Titanium Metal by O. C. Ralston & F. J. Cservenyak, Bur. Mines.

Optical Metallography of Titanium by W. L. Finlay, J. Resketo & M. B. Vordahl, Remington Arms Co., Inc.

Titanium Alloys by B. W. Gonser, Battelle Mem. Inst.

Preparation and Properties of Titanium-Base Alloys by P. H. Brace, W. J. Hurford & T. H. Gray, Westinghouse Elec. Corp.

Fabrication of Ti-Rich Alloys—Mechanical Properties of Some Wrought Alloys by E. I. Larsen, E. F. Swazy, L. S. Busch & R. H. Freyer, P. R. Mal-lory & Co.

Effect of Carbon in Titanium Metal Ingots by E. A. Gee, J. B. Sutton & W. J. Barth, DuPont.

Titanium Tetraiodide—Preparation and Refining by W. B. Blumenthal & H. Smith, Natl. Lead Co.

Organic Compounds of Titanium-Tetraalkyl Orthotitanates, New Waterproofing Agents by R. J. Speer & D. R. Carmody, Texas Research Foundation.

Titanium in Porcelain Enamels by G. H. Spencer-Strong & R. F. Patrick, Pemco Corp.

Photochemistry of Rutile by W. A. Weyl & T. Forland, Penn. State Coll.

Titanate Ceramics for Electrochemical Purposes by H. Jaffe, Brush Development Co.

143 references.—INCO.

6.3

Titanium as High-Strength Light-

weight Material. O. C. Ralston. *Sheet Met. Ind.*, 26, 2,132-2,133 (1949) Oct.

The metal titanium ranks with the lightweight metals because it is only slightly more than half as dense as iron, but twice as dense as magnesium. It is the fourth most plentiful of the metallic elements that are stable in air and can be used structurally. The industrially pure form of titanium attainable without high expense is a metal with the strength and corrosion resistance of the stainless steels and only half as heavy. One pound of titanium will do the work of two pounds of a good type of stainless steel and four times the work of common structural mild steel. Titanium is nearly six times as strong as aluminum of like purity and four times as strong as magnesium. The corrosion resistance is even more promising. To date, its performance in sea water probably has been investigated more completely than in other corrosive mediums. The high melting point of titanium has other attractions; however, hot titanium in contact with air scales in a similar manner to iron and in about the same temperature ranges. Either protective covering or alloying with suitable elements to protect it will be necessary. Much study is under way, but results are not yet available.—TIME.

6.3, 3.5

Cemented Titanium Carbide. J. C. Redmond and E. N. Smith. *Met. Trans.*, 185, 987-993 (1949) Dec.

A study was made to determine the properties of compositions consisting of titanium carbide and an auxiliary metal and to improve the oxidation resistance of such compositions. The compositions were prepared by powder metallurgy methods, such as used for cemented tungsten-carbide compositions. The results indicate that the cemented titanium-carbide compositions have transverse rupture strengths up to 175,000 psi or 75% greater than previously reported in literature. Either cobalt, nickel, or iron may be used as an auxiliary metal. The two former metals appear to be nearly the same in titanium-carbide compositions, while iron is somewhat inferior. Compositions containing only titanium carbide and an auxiliary metal are considerably superior to tungsten-carbide compositions with respect to the character of the oxidation products. It was also found that the addition of minor percentages of tantalum carbide or of columbium and tantalum carbide reduces the oxidation rate of the titanium-carbide compositions to very small values at temperatures up to 2200° F. Taking into consideration the strength, oxidation, resistance, thermal expansion, and conductivity, these compositions offer excellent possibilities as high-temperature materials.—TDD.

6.3, 4.3, 4.4

High Silicon Acid-Resisting Iron. R. V. Riley. *Intern. Chem. Eng. & Process Inds.*, 39, No. 1, 30-34 (1949) Jan.

Discussion includes corrosion resistance to various acids, chemical composition, production of the alloy, patterns, molds and core requirements, other foundry considerations, and design of Si-iron castings.—INCO.

6.3, 8.1

Corrosion of Brass (Stair Rails). H. H. Symonds. *Metal Ind.*, 76, No. 1, 3-4 (1950).

S. describes a visual and microscopic investigation into the causes of staining



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and apparent corrosion at isolated spots on brass stair rails after bronzing and lacquering. Staining was probably due to the type of oil used in shaping the strip, and was removable by immersion in chromic acid or bichromate solution. Corrosion was due to the fact that the bronzing, although sufficient to provide a copper color, was insufficient for protection. Cleaning for 5 min. in strong hydrochloric acid and recoppering was the only remedy.—MA.

6.3, 3.5

Stress-Corrosion Cracking (of Brass). H. H. Symonds. *Metal Ind.*, 76, No. 2, 33 (1950).

Three small brass (copper 68.22%) bobbin shields showing various degrees of cracking were examined under the microscope. The material was of satisfactory composition, the cracking being due to stress-corrosion caused by storage in a corroding atmosphere. The remedies suggested were either the use of copper for the pressings, or low-temp. stress-relief annealing (250°-300° C) for the brass pressings.—MA.

6.3

New Uses for Cobalt-Base Spring Alloy. R. F. Waindle, Elgin Nat. Watch Co. *Metal Prog.*, 56, No. 6, 808-811 (1949) Dec.

Examples of uses of Elgiloy other than as mainsprings in watches. Tables show typical physical and mechanical properties, comparative corrosion resistance in 50 hr. tests with 18-8 Mo and 17 Cr-Fe, and a check list of performance requirements of commercial applications. Diagrams show ultimate strength of flat spring stock and hardness of various alloys. Elgiloy, which contains 40 Co, 20 Cr, 15 Ni, 7 Mo, 2 Mn, 0.04 Be, 0.15 C and balance Fe, has good high temperature properties and good corrosion resistance.—INCO.

● Non-Ferrous Metals & Alloys—Light

6.4, 3.2

Intercrystalline Corrosion of Aluminum Alloys (original text in Russian). A. E. Golubev. *J. Phys. Chem. (USSR)*, 23, No. 9, 1116-26 (1949) Sept.

An analysis is given of the results obtained in studying the corrosion stability of intermetallic MgZn₂ compounds, which takes place during the hardening phase of aluminum-zinc-magnesium alloys. Metallurgists long ago have developed alloys based on aluminum with an addition of zinc and magnesium, the strength of which was higher than that of Duralumin. It was established that only these alloys possess the best mechanical properties where intermetallic compounds of MgZn₂ are found in their hardening phases. These alloys possess a relatively good corrosion stability; however, at a simultaneous effect of tensile forces and corrosion agents the alloys acquire a tendency toward "corrosional cracking." Corrosion cracking does not form any characteristic peculiarities in aluminum base alloys, and it is known that other metal alloys like brass (seasonal cracking), electron, etc., are also subjected to such kind of disintegration. The potential of the intermetallic MgZn₂ compound in the process of dressing in a 3% NaCl solution changes to 0.567 V. The potential in the dressing of magnesium and zinc changes only to 0.068 V. The process of

disintegration of intermetallic MgZn₂ compounds begins with the change-over of the magnesium-ion atoms in the solution. The zinc ions found in the solution are proportional to the increased period of corrosion of intermetallic MgZn₂ compounds. The process of corrosion of aluminum-zinc-magnesium alloys under stress, the so-called corrosion cracking phenomenon, is specified in the basic transition of the intermetallic MgZn₂ compounds in the magnesium solution.—TDD.

6.4

Investigation of Purity of Aluminum-Silicon Die Casting Alloys. Donald L. Colwell. *ASTM Bull.*, 1950, 51-53, Jan.

Summarizes work on outdoor-exposure, salt-spray, and salt-solution-immersion tests on 5- and 12%-Si Al die-casting alloys made since 1934. The results, which are scattered through several volumes of ASTM Proceedings, indicate that commercial grades are as corrosion resistant as high-purity grades. Conclusions are based on mechanical properties after exposure as well as depth of attack, weight loss, etc.—BLR.

6.4, 3.4

Defects of Anodic Oxidation Due to the Presence of Chlorides (Defauts d'oxydation anodique dus a la presence de chlorures). J. Herenguel and R. Segond. *Revue de l'Aluminium (France)*, 26, No. 152, 52-54 (1949) Feb.

Anodic oxidation causes the formation of an anhydrous oxide film on aluminum which will check electrolysis if the character of the pores was not formed by attack on the electrolyte. A very violent attack, due particularly to the presence of chlorides, dissolves this film completely and causes the aluminum to deteriorate. These chlorides can be found in the electrolyte, producing a generalized attack; or they are assimilated in the aluminum as a result of either a poor refinement of metal conduit or welds insufficiently freed from their flux by washing, leading to local attacks. The electrolytic bath must have a chlorine strength of less than 0.4 percent. It is concluded that chlorides create a great disturbance in the mechanism of anodic oxidation since the very active chlorine ions enter deeply into the interior of the oxide film during oxidation; they provoke severe corrosion. With the metal containing chloride inclusions, involving very severe local corrosion, the chlorine ions remain in elevated concentrations, and produce intense anodic dissolution. These inclusions can have various origins: foundry flux for rolled pieces, welding flux for welding assemblies, and bad fluxes after soldering. The use of welding flux containing only fluorides which do not involve this type are recommended. The electrolytic bath itself can contain chlorine ions. When their strength is weak enough, the oxidation film is attacked generally with a lessening of stiffness. If the strength exceeds a limited value, local corrosion appears as in the case of chloride inclusions. The strength of chlorine in the electrolytic baths must therefore be verified regularly.

6.4, 5.9

Finishes for Aluminum. 124 pages. 1949. Reynolds Metals Company, Inc., Louisville, Ky. (TS555 R33f.)

Considers characteristics and properties of Al, various processes for applying surface finishes, finish characteristics, controls, and tests. Includes photographs and tabular data.—BLR.

6.4, 3.7

High-Purity Aluminum (Raffinal and Reflectal): Properties and Applications in the Light of Recent (German) Publications. Rolf Schnell. *Leichtmetall Inform.-Dienst*, 2, No. 1/2, 11-16 (1949).

After surveying the development of its production, S. describes the properties of high-purity (99.99%) aluminum with special reference to its propensity to develop a large grain-size which limits its application. The highest purity obtained is 99.9986%, the impurities being silicon, iron, and copper up to 0.0005% each. High-purity aluminum is now widely used in the electrical and chemical industries and also as cladding material on aluminum alloys. Electrolytically polished and anodized high-purity aluminum has excellent reflection properties which are retained over a great length of time, but its low strength restricts its use. An addition of 0.3-1.0% magnesium improves its strength without altering the corrosion-resistance and the polishing and anodizing characteristics. This alloy is used for reflectors and imitation jewelry. Up to 0.7% silicon, 0.7% iron, and 5% magnesium have no effect on the corrosion-resistance of 99.99% aluminum, but as little as 0.005% copper reduces it slightly and > 0.02% reduces it markedly. Titanium (0.1%) effects grain refinement without impairing the properties of the aluminum apart from the anodizing property. An addition of silicon 0.04, iron 0.2, copper 0.1, or magnesium 5% has no effect on the anodizing properties, but even traces of titanium have an effect.—MA.

6.4

Development and Properties of a High-Test Malleable Aluminum Alloy. (In German.) H. J. Seemann. *Metall*, 3, 374-375 (1949) Nov.

Extensive tests were made to investigate the malleability, mechanical strength, and resistance to stress corrosion of an Al alloy containing 9% Zn, 1.5% Mg, 2.5% Cu, and 0.5% Mn. Results show that this alloy compares favorably with Duralumin, except in its resistance to stress corrosion when annealed at 100° C.—BLR.

6.4, 5.9

Can You Use Chemical Methods in Finishing Aluminum? *Steel*, 125, 53-56, + (1949) Oct. 31.

Surveys wide variety of protective and decorative finishes which can be produced economically by strictly chemical processes. Surface conversion coatings, frosted finishes, diffuse reflector finishes, various types of etched surfaces, chemically produced oxide coatings, and a method for producing bright chemical polish on aluminum by dipping are described.—BLR.

6.4

How to Design Aluminum Bridges. D. B. Steinman. *Eng. News-Record*, 143, No. 9, 198-202 (1949).

Economic and constructional considerations regarding the use of aluminum in bridge-building are presented and discussed. The relative costs of structural aluminum per sq. in. in cross-section and for equal tensile design strength are 1.29 and 1.41 times those of silicon steel, and 1.45 and 1.19 times those of carbon steel, respectively; further developments may bring these ratios closer to unity, but in any case there are applications in which the savings in weight or dead-load outweigh the price difference. S. indicates requisite physical properties of various bridge components, and recommends ap-



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propriate aluminum alloys; other aspects mentioned include corrosion-resistance, temp. effects, welding, and the use of extruded shapes.—MA.

6.4, 2.2, 5.9, 5.3

The Corrosion-Resistance of Duralumin in Different Conditions of Finishing (Surface Cladding). L. J. G. van Ewijk. *Metaux et Corrosion*, 24, No. 291, 261-273 (1949).

The results are described of comparative corrosion tests on Duralumin sheet protected as follows: a) unprotected, b) anodized (Alumilite process), c) clad with Al-Mg-Mn alloy, d) as c) but anodized, e) clad with 99.5% aluminum, f) clad with 99.99% aluminum. Specimens

of each of the above were immersed in distilled water (1 year) and running water (2 months) and exposed to the action of an urban atmosphere (6 years). Both the waters used in the tests contained 3% sodium chloride and 0.1% hydrogen peroxide (maintained constant). After exposure the specimens were subjected to tensile tests and to visual examination; the thickness of the anodic films was also measured. The unprotected Duralumin was heavily attacked by the salt solutions. Resistance to corrosion by salt solutions is somewhat improved by anodizing, but not sufficiently to justify the use of anodized material in aircraft. The tensile and yield strength of anodized Duralumin was little changed by six years' atmospheric

exposure, but the elongation fell if the film was thin ($8\ \mu$). The tensile and yield strengths of unprotected Duralumin fell from 42.5 to 35.2 kg/mm² and 28.5 to 26.3 kg/mm², respectively; the elongation fell from 23 to 16%. The clad Duralumins all showed excellent resistance to corrosion by salt solution and atmospheric exposure, there being little difference between the three types of coating; material clad with 99.5% aluminum seemed slightly inferior to the other two. It is doubtful whether anodizing improves the corrosion-resistance of clad sheet.—MA.

6.4, 1.6

Technology of Light Metals. Alfred von Zeerleder. Translated by A. J. Field from the First Swiss Edition. Sup. Roy. 8vo. Pp. xiv + 366, with 63 tables and 396 illustrations. 1949. New York: Elsevier Publishing Co., Inc. (\$6.00); London: Cleaver-Hume Press, 42a South Audley St., W. 1. (45s.).

Intending users of this English translation would no doubt wish to know how it is related to the previous similar books of the same author. The original "Technologie des Aluminiums und seiner Legierungen" was published in Leipzig in October 1933, and an English translation by A. J. Field of the second German edition of May 1935 was published in 1936. A shorter, partial version of the translation was also available. Third and fourth editions in German were prepared by the author, the date of the editions being given as 1938 and 1943, respectively. An English translation by J. Juxon Stevens of the third edition of 1938 was published by Messrs. High Duty Alloys, Ltd., in 1948. It is doubtful whether many copies of the fourth German edition of 1943 are now in existence, as we believe it was mainly destroyed during the course of the attack on Germany. In 1947 the new book "Technologie der Leichtmetalle" was published in Zurich, and the present translation under review is again the work of Mr. A. J. Field.

It is worthy of note that Professor von Zeerleder says, in his preface to his new book, "Technology of Light Metals," that as a very complete bibliography, including patent references, was given in the fourth German edition of "Technologie des Aluminiums" there is no need for it in the new publication. In the absence of the fourth edition, some use can be made of the English translation of the third edition for this purpose, where Mr. Stevens has translated the extensive bibliography, although omitting the German patents. If, as we expect, the bibliography of the third edition was brought up to date for the fourth edition, Professor von Zeerleder might consider whether a separate publication of the bibliography would be justifiable.

The book is intended for the technologist or man-in-the-works, and it does supply a text-book in which information on most phases of production and fabrication can be discovered. With this general objective in mind, however, it can be seen that the author has had difficulty in judging what to include and what to leave out, so that there are some places where the degree of detail is quite different. Thus, for example, although drawing and extrusion defects are described, there is no mention under "Rolling" of the various types of blistering of sheet with which the technologist is concerned. Again, although no mention is made of the method of preparation of the clad strong sheet alloys, some intriguing mention of the



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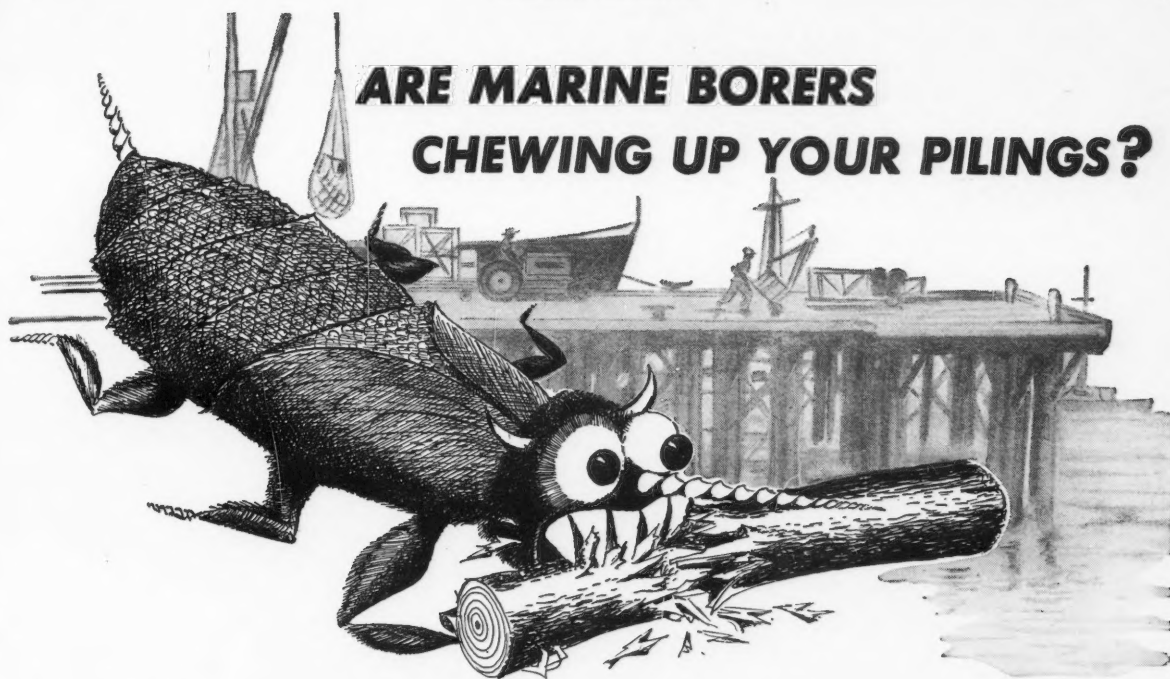
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effect of continuous-casting conditions on the cast-block and subsequent structures is made (see Fig. 138).

Some results of the method of arrangement strike one as a little unorthodox, as, for example, the modification of aluminum-silicon alloys which, following another section on fluxes, is found as a subsection of "Melting Furnaces." Similarly, Chapter IV on "Design and Construction" uses some supporting data and arguments which might have logically been placed in other sections, notably those on "Forging" and "Surface Treatment."

In a few places, contradictory statements are made. Thus on p. 22, we find under "Complex Alloys" the comment, "Even a small amount of zinc in the absence of magnesium perceptibly impairs corrosion-resistance of aluminum alloys," while on p. 69 it is stated, "Zinc only begins to have a detrimental effect in contents over about 1%." This apparent contradiction might be cleared up by amplification of the first comment.

Notwithstanding these criticisms, there is no doubt that this book will be found extremely useful to the practical man, particularly in the aluminum industry. He will find that while the whole book is of general interest, and contains much useful information, pages opposite the many useful tables will become thumbed with repeated reference.—MA.

● Non-Metallic

6.6

Developments in Wood Preservatives. J. O. Blew. *Chem. Inds. (U. S. A.)*, **64**, 218-23 (1949) Feb.

After pointing out the need for wood preservatives and the qualities of an ideal preservative, the author compares those available. Although chromated zinc chloride is the most widely used of the waterborne salt preservatives, there is no conclusive evidence to suggest that it is superior to ordinary zinc chloride which possesses the advantages of low cost, cleanliness and absence of fire hazard. Zinc meta-arsenite is amongst other preservatives mentioned, but its use has recently declined.—ZDA.

6.6

Efflorescence and Crystallization on Masonry. H. Rabate. *Trav. Point.*, **4**, No. 9, 407-8 (1949).

Efflorescence on masonry may be due to sol. salts in the soil, bricks or cement. It is usually due to sulfates, especially CaSO_4 . Sulfates in bricks may be rendered inactive by the addition of witherite to the clay.—RPI.

6.6, 3.5

Glass Corrosion Tests on Refractories. J. J. Webber, A. C. Siefert & F. V. Tooley, Owen-Corning Fiberglass Corp. *Am. Ceramic Soc. Bull.*, **29**, No. 2, 52-54 (1950) Feb.

Methods of evaluating refractories with respect to their resistance to glass corrosion are described. This corrosion refers to the eating and wearing away of refractories by glass and includes the effect of erosion. Refractories are progressively screened in a crucible flow test and a simulated service test before being accepted for production trials. Both of these tests employ a fresh glass flow principle which is considered essential. The crucible flow test is a fast method of evaluation in a qualitative manner only. The simu-

lated service test is a necessary second step in the procedure to obtain more quantitative data from which predictions can be made.—INCO.

EQUIPMENT

● Engines & Turbines

7.1, 6.2, 3.5

Metals at High Temperatures in Steam and Gas Turbines. Review of Present Position—I and II. J. M. Robertson. *Iron and Coal Tr. Rev.*, **159**, 1275-1280; 1333-1338 (1949) Dec. 2, Dec. 9.

Deals with high-temperature corrosion, surface oxidation, effect of S dioxide, and reproducibility of properties, suitability for working, welding, machining and costs, metals used in steam and gas turbines, C-Mo and Cr-Mo steels, non-stainless hardenable ferritic steels, stainless, hardenable ferritic steels, austenitic steels, and other alloys. Table of typical percentage compositions of 23 steels is mentioned. Only a passing reference to alloys other than steels is made.—INCO.

● Valves and Pipes

7.2

Valve Type Related to Operating Needs. *S.A.E. J.*, **57**, 71-73 (1949) Dec. Based on "Recent Trends in Engine Valve Design and Maintenance for Automotive and Diesel Engines," by Norman Hoertz and R. Max Rogers.

Surveys properties of the various alloy types, with emphasis on their behavior in service (corrosion resistance, thermal resistance, physical and mechanical properties). Effects of design variations are shown.—BLR.

● Pumps, Compressors, Propellers & Impellers

7.3

Positive Displacement Pump for Corrosive Fluids. E. E. Glenn and N. Hackerman. *Rev. Sci. Inst.*, **21**, No. 2, 148-149 (1950) Feb.

A positive displacement-type pump in which there are no metal parts exposed to the fluids and so gases, liquids, or mixtures can be pumped without corrosive effects to the pump. The tubing is Tygon within rubber tubing.—INCO.

● Heat Exchangers

7.4, 6.3, 3.6, 3.3

Corrosion of Condenser Tubes. P. F. Thompson. Austral. Council for Scientific and Industrial Research, Division of Aeronautics. Report Sm. 113; Austral. Scientific Liaison Office, Washington, Australian Technical Papers No. 1665 and 1666 (1948) June.

Part I. Electrochemical Characteristics of Copper, Zinc and Some Brasses. Previous work on the corrosion of condenser tubes is summarized, and illustrated examples of corrosion effects are given.

Time and temperature potentials were determined for copper and various

brasses in fresh and salt water under conditions of aeration and deaeration and regulated abrasion. It is demonstrated that sodium chloride depresses the potential of zinc, copper, and their alloys, and also modifies the aeration potential.

The use of large electrodes is censured because of the results obtained with "microelectrodes" of copper and brass which give an instantaneous response when an air bubble strikes the minute areas; the bare metal becomes cathodic and not anodic as commonly thought. Since air impingement renders the potential more positive, present theories on the mechanism of impingement attack must be revised.

Part II. The Effects of Cuprous Ions, Sodium Chloride and Air Bubble Impacts on the Electrode Potentials.

The cathodic activity of cuprous ions from cuprous oxide was investigated in tap and salt water, and the effect of complex ion formation on the corrosion process is discussed. In sea water, the oxidizing potential of these cuprous ions is sufficiently high to corrode brass. Cuprous chloride, owing to its greater solubility, gives a slightly more positive potential.

Though potentials due to cuprous ions are overshadowed by those of dissolved oxygen, their cathodic properties may become fully effective under conditions where aeration is limited. Steady corrosion will continue as long as there is a reserve of cuprous ions, but this supply cannot be maintained without further production of cuprous oxide, i. e., without further corrosion by differential aeration.

Concentrated salt solutions exhibit very little divergence in their heating and cooling deaeration-aeration potential curves. Diminished solubility of oxygen, which has only a negligible effect on the oxygen (air) potentials, is not the cause of this.

The direct impact of air bubbles on Admiralty and aluminum brass electrodes does not result in mechanical removal of a film, but causes corrosion by an electrogalvanic mechanism. Potential measurements made simultaneously on screened and unscreened microelectrodes of the same metal showed that the impact causes the electrode to become cathodic; even when the small abrasive action of a bubble is greatly increased by the sand-blast effect of powdered silica, the protected electrode not subject to abrasion or impingement was always anodic.

Part III. Effects of Biological Factors and Crystal Structure With Concluding Remarks.

Suggestions that corrosion may be instigated or accelerated by bacterial and other organisms are discussed, and fundamental thermodynamic objections are raised to the possibility of bacteria acting as cathodic agents. Complex ions formed with sulfides, ammonia, and similar bacterial breakdown products of organic matter may decrease the anodic potential of a corrosion cell, but only if appreciable amounts of organic matter are present. The latter may form oxygen screens, but these are not necessarily more effective than colloidal or permeable masses of inorganic material.

The reduction of potential by decomposing organic matter was found to be little greater than that obtained by complete deaeration alone in salt water. The influence of ammonia formed in polluted sea water was much too small to appreciably affect corrosion.

Differential aeration leads to corrosion by dissolution of ionized material or ox-

ides at grain boundaries. The superior resistance to this type of corrosion of aluminum brass over Admiralty brass may be due to the formation of spinel types of oxide during fabrication. Such oxides containing alumina would not be soluble in salt water, whereas those of zinc and copper form soluble complex ions with chloride ions. Experiments show that corrosion by differential aeration of both Admiralty and aluminum brass is intensified at drawing defects which were invisible before corrosion advened.

The revolutionary suggestion is made, with certain provisos, that high velocities and turbulence may not be a disadvantage in condenser tube practice. If the conclusion is correct, that a clean brass or copper surface uniformly and thoroughly aerated is cathodic, then the removal of all screening material of sludge and corrosion products would be an advantage. Their removal from condenser tubes by rapid currents of water would not only eliminate corrosion by differential aeration and subsequent cathodic copper deposition, but would greatly increase heat transfer.

INDUSTRIES

• Group I

8.1, 1.7

Fundamentals of Corrosion and Its Mitigation. E. W. Moore, W. H. Sears and L. Rubin. *Water and Sewage Works*, 85-88, 1950, Feb.

The committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation was established by the N.E.W.W.A. in 1942. A meeting in July, 1948, was held to determine its future course. Discussion led to the conclusion that the committee might partially fulfill both objectives by adopting the following course of action: 1. To prepare a basic report which would, insofar as possible, summarize present knowledge on corrosion; 2. Using this basic report as a point of departure, to examine critically the new developments in the field at such times as the committee considers that sufficient evidence is at hand for examination and reporting. This installment contains Part 1, Definitions, and Part 2, Fundamental Reactions, of this basic report.—GPC.

• Group IV

8.4, 1.2

Corrosion in the Petroleum Refinery. H. Kaye. Paper before Council of British Manufacturers of Petroleum Equipment, Manchester. *Brit. Pet. Equip. News*, 1, No. 4, 27-31 (1949).

Cost of corrosion to consumer in petroleum industry given as £1 per ton on all petroleum products and covers wet, dry, and stress corrosion. Detailed information on behavior of components made from number of materials (including 18-8 Monel, stainless steels) in specific components is given. Reference to cone of Staybrite 254A (replacing Staybrite F.M.B.), which proved porous is made. Sealing with Bakelite is beneficial. Cone has been in service for some three months as part of drying column used in Edeleanu plant. R. ex 254A, which is presumably the material referred to, contains 17.73 Ni, 18.41 Cr, 0.08 C.—INCO.



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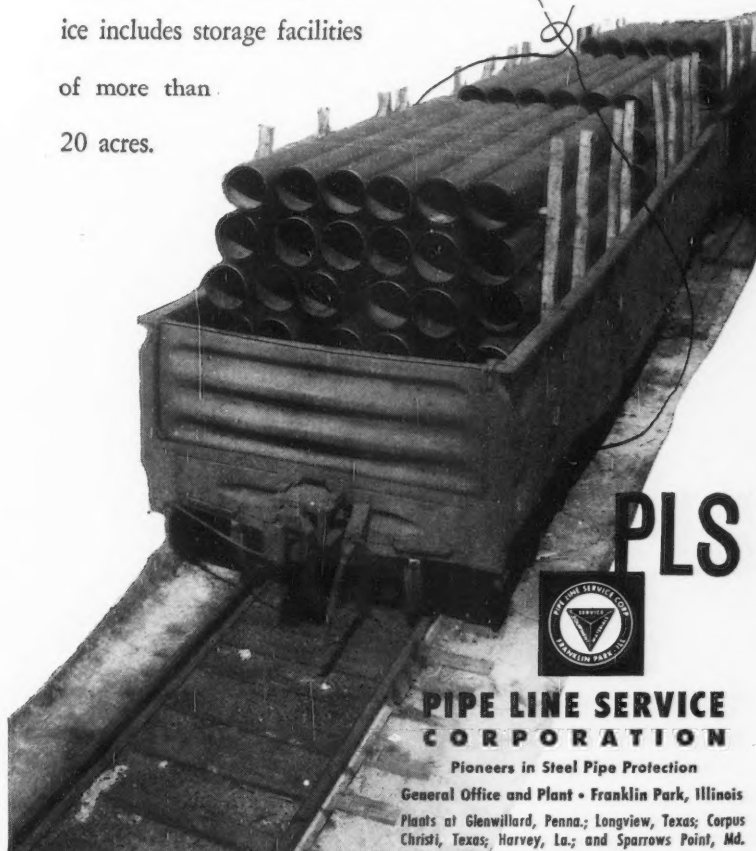
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8.4, 5.7

Neutralization as a Means of Controlling Corrosion of Refinery Equipment. E. Q. Camp and C. Phillips. *Corrosion*, 6, 39-46 (1950) Feb.

This paper summarizes the results obtained by using neutralizers as a means of controlling corrosion of refinery equipment. The methods employed in injecting sodium hydroxide, ammonia, and lime are presented. The ammonia distribution system serving the refinery is described. Information is presented in detail on the results obtained on the use of ammonia in controlling corrosion of equipment in connection with distillation, cracking, gas absorption, debutanization and steam systems. The injection

of sodium hydroxide and lime into cracking units is discussed as well as the use of sodium hydroxide and soaps in controlling corrosion of distillation equipment.—GPC.

8.4, 5.8

Field and Laboratory Tests of Sodium Chromates and Alkalies for Controlling Corrosion in Gas Condensate Wells. Part 5. Analysis of Field Test Results. C. K. Eilerts and others. *World Oil*, 129, 156-158, + (1949) Nov. Part 6. (Concluded.) *Ibid.*, 129, 160-162, + (1949) Dec.

Discusses characteristics of a chromic-oxide deposit found in the tubing collars of well in the 3000-7100 ft. zone and also as a continuous internal coating below this level. Gives results of investigation of physical texture and composition, and of solvent tests on this

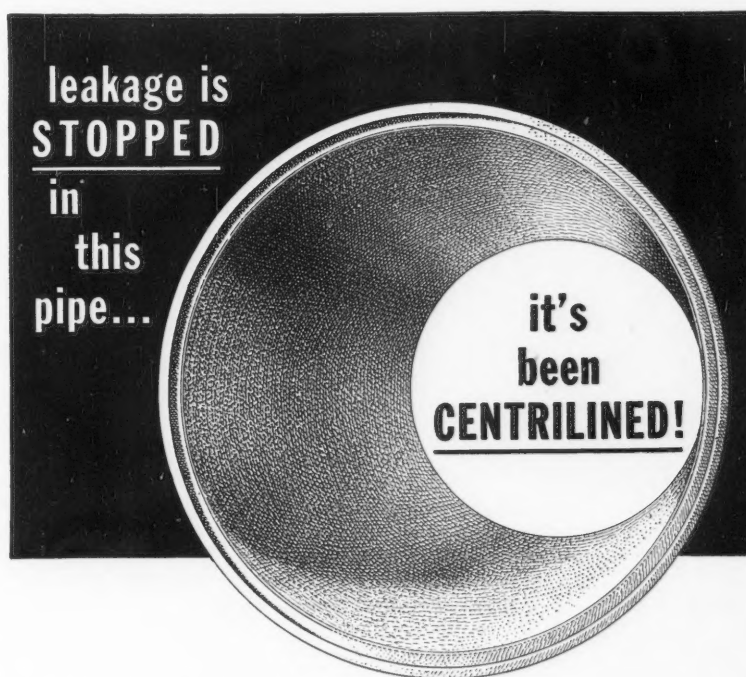
material. Results indicate that 15% HCl will remove deposits of reduced chromates. Presents analysis of costs of chromate treatment and a discussion of needed additional research.—BLR.

• Group IX

8.9

Modern Automobiles—Places Susceptible to Corrosion and the Prevention (of Such Corrosion). A. Kufferath. *Metallüberfläche*, 3, No. 3, 76 (1949).

K. discusses corrosion in automobiles due to: 1) the entrance of dirty rain-water, 2) the use of soft rubber, containing free sulfur, as packing material for joints, 3) exhaust gases, and 4) vibration. Methods for the prevention of such corrosion are noted.—MA.



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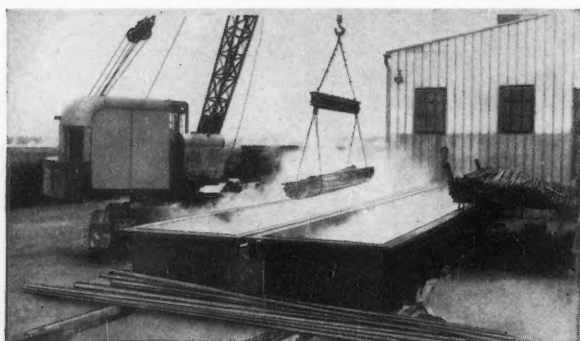
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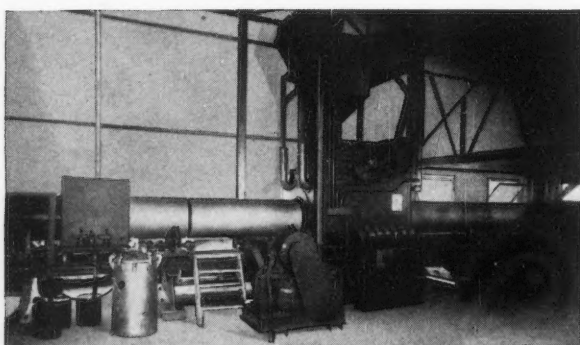
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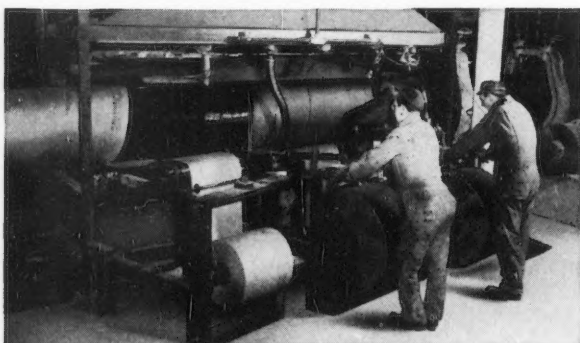
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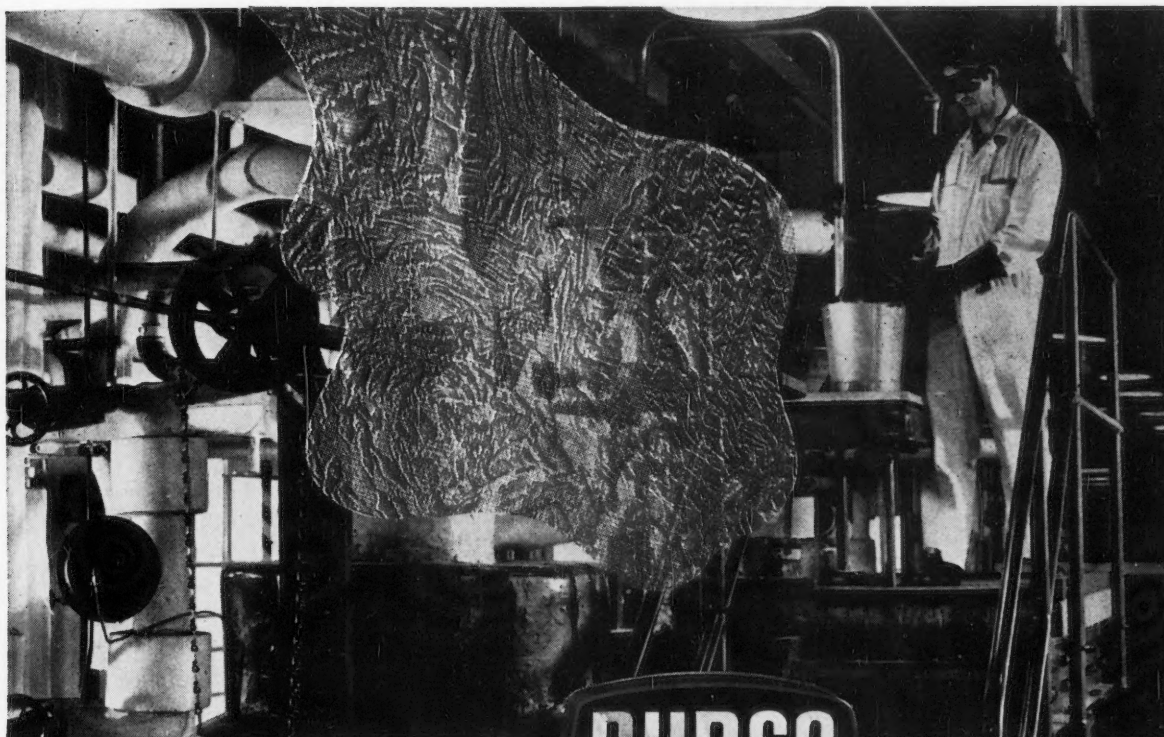
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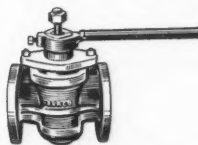
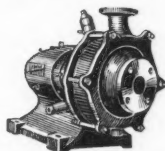
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